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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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Governor General of Canada

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COVER: Prairie vegetation in the Red Cloud Pioneer Cemetery, a location managed by the Cramahe Township Cemetery Board to protect both the human history and the prairie vegetation that was part of it. Native prairie was eliminated from most of the landscape by conversion for subsistence agriculture, but the plant communities in the early pioneer cemeteries were protected from the severe impacts on the surrounding landscape. In the foreground is a shrub of the Prairie Willow (*Salix humilis*) with Bluestem grasses (*Andropogon gerardii*, *Schizachyrium scoparium*), Black Oaks (*Quercus velutina*) on the right and native Red Pines (*Pinus resinosa*), common on the former plains, on the left. See article by Catling pages 1-20.

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Promoting the study and conservation
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THE OTTAWA FIELD-NATURALISTS' CLUB

OTTAWA

CANADA

The Extent and Floristic Composition of the Rice Lake Plains Based on Remnants

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Catling, Paul M. 2008. The extent and floristic composition of the Rice Lake Plains based on remnants. *Canadian Field-Naturalist* 122(1): 1-20.

A study of the floristic composition and extent of the Rice Lake Plains in central southern Ontario was undertaken to provide a basis for protection and management and to contribute to a better understanding of pre-settlement vegetation. During field reconnaissance 42 remnant sites were discovered. Complete species lists were generated for 24 of these sites and a total of 260 native species was recorded of which 61 were present at more than half of the sites. Less than 10% of the native flora of dry, open ground is believed to be extirpated. The most frequent species and those dominating many of the remnants included *Andropogon gerardii*, *Carex siccata*, *Ceanothus americanus*, *Pteridium aquilinum*, *Sorghastrum nutans*, and *Toxicodendron rydbergii*, all of which are characteristic dominants of tallgrass prairie and related habitats in the midwest. It is believed that both composition and frequency are much the same, but not exactly the same, as existed in pre-settlement times. A principal coordinate analysis based on Jaccard's coefficient derived from a matrix of presence/absence data for 84 regionally rare species in 24 sites revealed three major groupings: (1) open sand and characteristic sand barren flora, including *Dichanthelium sabulorum*, *Carex merriitt-fernaldii*, *Cyperus lupulinus*, *Polygonum douglasii*, *Selaginella rupestris*, and *Sporobolus cryptandrus*; (2) prairie sites with *Desmodium canadense*, *Monarda fistulosa*, *Penstemon hirsutus*, *Ranunculus rhomboideus*, and *Schizachyrium scoparium*; (3) high-diversity sites with savannah vegetation, including species characteristic of both prairie and open woodland, including *Asclepias exaltata*, *Desmodium glutinosum*, *Erigeron pulchellus*, *Solidago arguta*, and *Taenidia integerrima*. Correspondance analysis suggested a succession from sand barren to woodland and ordered species along a successional axis. In addition to three major associations, there was some regional variation with closer sites sharing species such as *Lupinus perennis*, *Liatris cylindracea* and *Dichanthelium oligosanthes*. The probable extent of plains vegetation revealed by remnants was determined by overlaying remnant sites on the soil landscapes and soil types to determine the extent of the associated soil or landscape thus providing a clue to the extent of the plains vegetation. Results of both the soil landscape and soil data analyses were subjected to restrictions based on exposure, elevation and historical information so as to develop a concept of minimum area. The minimum area of plains vegetation including prairie, sand barren and savannah was estimated to be 263 km² on the basis of distribution of appropriate soils and 590 km² on the basis of soil landscapes. Thus the Rice Lake Plains included an area of prairie, savannah and sand barrens approximately 600 km² in extent and extending as an essentially continuous band 123 km long and up to 25 km wide along the top and north slope of the Oak Ridges Moraine from the Ganaraska Highland west of Rice Lake eastward to the Murray Hills and the Trent River and was one of the largest areas of plains vegetation in the eastern Great Lakes region.

Key Words: Prairie, tallgrass prairie, sand barrens, savannah, vegetation, phytogeography, protection, invasive aliens, Rice Lake, Great Lakes region, Ontario.

Once a vast area of open prairie and savannah, the Rice Lake Plains were largely destroyed during the period of early settlement between 1875 and 1885 (Catling et al. 1992). Over the past decade there has been extensive interest in the protection and restoration of the scattered remnants (Figure 1) since prairie, savannah and sand barren (these often subsequently referred to as "plains vegetation") are among the most threatened plant communities on the continent and in Ontario less than 1% of this habitat (originally at least 2000 km²) remains (e.g., Carbyn and Catling 1995; Rodger 1998; Varga 1999). Not only are these remnants

major refugia of plant biodiversity (Clarke 2005; Hendrickson 2006) but they also contain significant diversity of other organisms (Figure 2). From an agro-economic perspective, they are a source of genetic material for development and improvement of new crops including those providing (some examples from the Rice Lake region in brackets) biofuel (Switchgrass), food (Hazel Nuts, Juneberries), forage (various grasses and forbs), fibre (grasses), medicine (Seneca Snakeroot), essential oils (Bergamot) and cut flowers (Blazing Star and Butterfly Milkweed), etc. (Dougan & Associates 2001*). As a result of recent



FIGURE 1. Restoration of native prairie vegetation at the Burnley Carmel Natural Area managed by the Nature Conservancy of Canada and Ontario Parks. A, prairie area recently burned to control invasive alien species and promote native prairie vegetation. A dead and burned stump of an invasive alien Scots Pine (*Pinus sylvestris*) in the foreground. B, New Jersey Tea (*Ceanothus americanus*), one of many species that decline or are extirpated by increasing invasive alien plant cover, but quickly increase in response to the natural process of fire, which was widespread in presettlement times.

interest, much information has been compiled (e.g., White 2003*) but several questions remain. Restoration requires information on what to restore and where. The composition and extent of North American prairies, savannahs and sand barrens are still not well understood, especially in eastern North America. This study of the Rice Lake Plains was designed to contribute to an understanding of (1) the vascular plant composition of the open areas (i.e., the plains), (2) variation in floristic composition, and (3) the likely extent of the Rice Lake Plains based on the distribution of remnants dominated by native species of dry, open ground.

Methods

(1) Floristic composition and Species lists

Between 1988 and 2006, the general region of the Rice Lake Plains was searched for remnants of natural vegetation of open (unforested) ground. Forty-two remnant sites were discovered. Remnants (Figure 3, Table 1) were defined as more or less dry, open areas dominated by native vegetation (80% of the cover). The remnants were located by driving roads and looking for native vegetation, checking likely localities discovered on aerial photographs, and determining pos-

sible locations through talking with local residents. Sites discovered during reconnaissance of the Ganaska section by W. Bakowsky, S. Varga and D. White (White 2003*) were included. The sites ranged from a roadside slope an acre (0.40 hectare) in extent to extensive areas of 30 acres (12.14 hectares) distant from roads. Species lists (Appendix) were developed for native species at each site. Complete species lists were generated for 24 of the remnants and these were dispersed throughout the region. Species present in the 24 sites were organized by the number of remnant sites in which they occurred so as to develop an idea of predominant species on the former plains. The scientific and common names used are mostly those of Kartesz and Meachum (1999*).

It is to be noted that reconstructing past floristic composition from remnants may have limitations including: (1) certain species may be lost because certain natural processes upon which they depend, such as fire, have ceased; (2) certain kinds of plant associations may be lost readily, such as mesic openings which would be subject to succession more rapidly than drier openings, leaving an incomplete record; (3) existing remnants may represent only certain associations in a landscape, such as those of slopes, so that



FIGURE 2. A, sandy meadow in open Black Oak (*Quercus velutina*) woods (site 32) dominated by Sand Dropseed Grass (*Sporobolus cryptandrus*), a typical habitat of the Mottled Sand Grasshopper, (*Spharagemon collare* (Scudder)), the Big Sand Tiger Beetle (*Cicindela formosa* Dejean) and many other increasingly localized insects. B, Mottled Sand Grasshopper inconspicuous on sandy substrate (thumbnail on left); C, Mottled Sand Grasshopper, frontal view.

the flora cannot be completely understood. As long as these limitations are acknowledged, floristic reconstruction on the basis of remnants can provide useful

information. In the present case, some limited historical data (Catling et al. 1992) are available for comparison allowing a degree of confirmation.

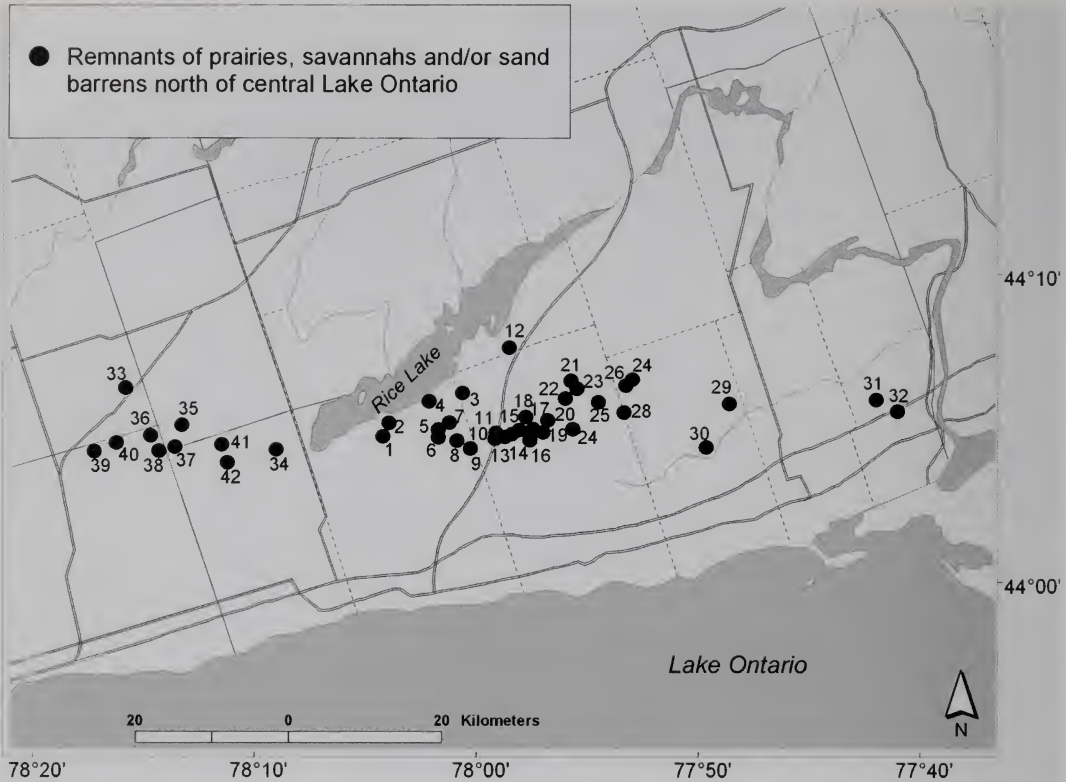


FIGURE 3. Rice Lake Plains region showing the locations of 42 remnant sites.

(2) Variation in floristic composition among sites

The relationship between sites was explored using Jaccard's coefficient, which emphasizes positive matches, with principal coordinate analysis (PCO). The Jaccard matrix was double centered, and the eigenvalues were extracted and plotted to illustrate major patterns of variation. To help compensate for distortion in this principal coordinate analysis and better reflect relationships between sites, a minimum spanning tree, connecting the most closely related locations based on the Jaccard matrix, was superimposed on the PCO.

Correspondence analysis (CA) was used to further explore major trends in site relationships and to determine how species related to these trends. In particular, the analogous plot of species and sites, based on Chi-square distances in each case and on the same eigenvectors, allows the species to be associated with site related trends in analogous multivariate space.

Only 24 of the 42 sites were used in PCO and CA analyses (Table 1), these selected on the basis of reliable and complete species lists. Since common species present at all sites, rare species present at a single site, and non-native species are all of limited value in classifying sites, only regionally rare native species pres-

ent at more than one site were used (84 species, Table 3). Regionally rare species are those known from less than 30 locations in the Oak Ridges moraine region where a location is defined as an occurrence removed at least 1 km from another. The analyses were done using NTSYS-pc version 2.11X (Rolfé 2000*). Additional information on interpretation is available in Legendre and Legendre (1983) and Pielou (1984).

(3) Extent of the plains

Soil landscapes and soil types were overlaid with the locations of remnant sites to determine on which soils and landscapes the remnants occurred. Both the soil, relating to features such as drought, and the landscapes, relating directly to ecological factors such as fire, are considered important in this context. The extent of the associated soil or landscape provided a clue to the extent of prairie, savannah and sand barren. This assumes that the occurrence of these open habitats is a consequence of soil and landscape attributes and that climate does not vary appreciably over the area of concern. This assumption is reasonable except to the extent that the slope toward Lake Ontario may have received more orographic precipitation and early observations suggest that this slope was forested (Traill

TABLE 1. List of sites with prairie, savannah and sand barren vegetation with their latitude and longitude and soil type. For sites the coordinates are approximate to protect landowners. Br = Brighton-Colbourne Sandy Loam, B = Bondhead Sandy Loam, Du = Dundonald Sandy Loam, Pg (P) = Pontypool Gravelly Sand (P, Pg), Pl = Pontypool Sandy Loam, Ps = Pontypool Sand. Asterisks (*) following a site name indicate those sites (with complete species lists) that were used in the statistical analyses.

Number	Soil	Name	Area (ha)	Latitude	Longitude
1	B,Du	Plainville Roadside Prairie *	0.2	44.0973	-78.2382
2	B,Du	Gore landing Hydro Line Prairies *	0.6	44.109	-78.2312
3	Pg,Ps	Harwood Plains ANSI Prairies *	4	44.1343	-78.1448
4	Du	Harwood South Prairie *	0.1	44.1274	-78.1843
5	Du,Ps	Oak Valley Prairie *	1	44.1032	-78.1630
6	Ps	Mill Valley West Sandhills *	5.6	44.0967	-78.1733
7	Ps	Harwood Prairie *	0.1	44.1091	-78.1602
8	Ps	Mill Valley Central Sandhills *	0.45	44.094	-78.1514
9	Ps	Mill Valley Central Prairies	5.79	44.0873	-78.1356
10	Ps	Mill Valley West Prairies *	2.11	44.0956	-78.1068
11	Ps	Mill Valley North Prairie Roadside *	0.38	44.1006	-78.1056
12	Pl	Alderville Prairies and Savannah *	8.82	44.1724	-78.09
13	Ps	Scout Camp Prairie *	0.31	44.0969	-78.0951
14	Ps	Northumberland Forest West Sand Barren	0.15	44.0994	-78.0871
15	Ps	Northumberland Forest Central Prairie	0.3	44.1028	-78.0783
16	Ps	Northumberland Forest South Prairies	0.49	44.0943	-78.0657
17	Ps	Northumberland Forest East Prairies	1.35	44.1038	-78.0616
18	Ps	Northumberland Forest North Prairies	2.68	44.1139	-78.0704
19	Ps	North Centreton Roadside Prairie *	0.48	44.101	-78.0505
20	Ps	South Peters Woods Prairie *	0.27	44.1112	-78.0448
21	Ps	Burnley Creek ANSI North – NCC North	0.16	44.1445	-78.0173
22	Ps	Burnley Creek ANSI North – NCC South *	1.4	44.1298	-78.0239
23	Ps	Burnley Creek ANSI North Roadside *	0.5	44.1379	-78.0102
24	Ps	Burnley Creek ANSI South	0.5	44.1039	-78.0153
25	Ps	Salt Creek – Russ Creek Prairies *	8.17	44.1266	-77.9851
26	Br,Ps	Salt Creek – East Prairies *	6.8	44.1405	-77.9531
27	Br,Ps	Red Cloud Cemetery Prairies *	0.25	44.1459	-77.9454
28	Ps	North Castleton Roadside Prairie *	0.44	44.1178	-77.955
29	Ps	Cold Creek (Goodrich–Loomis) *	1.64	44.1254	-77.8312
30	Ps	Cold Creek – Shiloh	0.6	44.0886	-77.8584
31	Br,Ps	Murray Hill North Prairie *	1.47	44.1288	-77.6585
32	Br,Ps	Murray Hill Sand Barrens *	0.66	44.1192	-77.6339
33	Ps	Cavan Creek Headquarters GF *	16.69	44.1386	-78.5406
34	Ps	Ganaraska Forest East ANSI GF	5.54	44.0864	-78.3632
35	Ps	Ganaraska Forest West ANSI – NE GF	2.76	44.1073	-78.474
36	P	Ganaraska Forest West ANSI – W GF	8.79	44.0983	-78.511
37	Ps	Ganaraska Forest West ANSI – Central	0.21	44.089	-78.4822
38	Ps	Ganaraska Forest West ANSI – SW	0.04	44.0852	-78.5009
39	Ps	Manvers West	0.02	44.0849	-78.577
40	Ps	Manvers East	1.16	44.0923	-78.5506
41	Ps	Robb's Hill North	4.97	44.0907	-78.4272
42	Ps	Robb's Hill South	0.24	44.0755	-78.4205

1885). Consequently, prairie was assumed not to be present on those parts of the open-habitat-associated landscapes and soils on the Lake Ontario side of the height of land between Lake Ontario and Rice Lake. The lack of remnants in this region supports this assumption. This methodology also assumes that soils, landscape and climate are the important attributes and that fire, a major factor, is mediated through these attributes. Nevertheless the extent is based on the landscape and soil where species of dry, open habitat survived, whereas they may have been present on more

mesic sites but not able to survive there due to competition and succession (in the absence of fire) or more intensive use of the landscape by humans. Consequently these methods very likely underestimate the amount of open habitat but provide a reliable minimum estimate.

Soil landscape coverages and soil type polygons based on the Northumberland (Hoffman and Acton 1974) and Durham (Webber et al. 1946) soil surveys were downloaded from the CANSIS website (<http://sis2.agr.gc.ca/cansis>) and plotted with site location data

TABLE 2. List of 84 species in ascending order of dimension 1 row factor values from correspondence analysis (Figure 6) indicating those species associated primarily with sand barrens (at the top of the list), those primarily associated with prairie and mixed associations (middle of the list) and those primarily associated with savannah (bottom of the list). Authorities for scientific names for species listed here are provided in the appendix.

Species	Factor
<i>Grindelia squarrosa</i> var. <i>squarrosa</i>	-1.6456
<i>Polygonum douglasii</i> ssp. <i>douglasii</i>	-1.6456
<i>Panicum virgatum</i> var. <i>virgatum</i>	-1.3525
<i>Arabis holboellii</i> var. <i>retrofracta</i>	-1.0794
<i>Selaginella rupestris</i>	-1.0561
<i>Dichanthelium linearifolium</i>	-1.0372
<i>Cyperus lupulinus</i> ssp. <i>lupulinus</i>	-0.8935
<i>Arabis hirsuta</i> var. <i>pyncocarpa</i>	-0.8821
<i>Sporobolus cryptandrus</i>	-0.8764
<i>Dichanthelium sabulorum</i> var. <i>thinium</i> (<i>D. columbianum</i>)	-0.8243
<i>Arabis divaricarpa</i>	-0.6198
<i>Linum sulcatum</i> var. <i>sulcatum</i>	-0.5672
<i>Carex merritt-fernaldii</i>	-0.5452
<i>Comptonia peregrina</i>	-0.4719
<i>Verbena stricta</i>	-0.4630
<i>Liatris cylindracea</i>	-0.4346
<i>Artemisia campestris</i> ssp. <i>borealis</i> var. <i>scouleriana</i>	-0.3506
<i>Dichanthelium depauperatum</i>	-0.3133
<i>Shepherdia canadensis</i>	-0.3129
<i>Arabis glabra</i>	-0.2685
<i>Helianthemum canadense</i>	-0.2514
<i>Carex muehlenbergii</i> var. <i>muehlenbergii</i>	-0.2371
<i>Calystegia spithamea</i> ssp. <i>spithamea</i>	-0.2176
<i>Lechea intermedia</i> var. <i>intermedia</i>	-0.2077
<i>Polygala polygama</i>	-0.1976
<i>Helianthemum bicknellii</i>	-0.1891
<i>Ceanothus americanus</i>	-0.1508
<i>Juniperus communis</i>	-0.1207
<i>Ranunculus rhomboideus</i>	-0.1188
<i>Asclepias tuberosa</i> ssp. <i>tuberosa</i>	-0.1124
<i>Carex tonsa</i> var. <i>rugosperma</i>	-0.1038
<i>Rosa acicularis</i> ssp. <i>acicularis</i>	-0.1037
<i>Quercus velutina</i>	-0.0982
<i>Carex siccata</i>	-0.0872
<i>Amelanchier stolonifera</i>	-0.0571
<i>Monarda fistulosa</i> ssp. <i>fistulosa</i> var. <i>fistulosa</i>	-0.0194
<i>Sorghastrum nutans</i>	0.0194
<i>Penstemon hirsutus</i>	0.0233
<i>Elymus trachycaulus</i> ssp. <i>subsecundus</i> (includes <i>unilaterale</i>)	0.0346
<i>Prunus pumila</i> var. <i>susquehanae</i>	0.0403
<i>Viola sagittata</i> var. <i>ovata</i>	0.0422
<i>Bromus kalmii</i>	0.0521
<i>Comandra umbellata</i>	0.0601
<i>Rosa blanda</i> var. <i>blanda</i>	0.0842
<i>Andropogon gerardii</i>	0.0863
<i>Rhus aromatica</i> var. <i>aromatica</i>	0.0883
<i>Schizachyrium scoparium</i> var. <i>scoparium</i>	0.0934
<i>Potentilla arguta</i> ssp. <i>arguta</i>	0.0983
<i>Viola adunca</i> var. <i>adunca</i>	0.1063
<i>Arctostaphylos uva-ursi</i>	0.1225
<i>Dichanthelium acuminatum</i> var. <i>acuminatum</i> (<i>D. implicatum</i>)	0.1269
<i>Helianthus divaricatus</i>	0.1311
<i>Vaccinium angustifolium</i>	0.1859
<i>Pinus resinosa</i>	0.1867
<i>Lilium philadelphicum</i> var. <i>philadelphicum</i>	0.1898
<i>Juniperus virginiana</i> var. <i>virginiana</i>	0.1903
<i>Potentilla simplex</i>	0.1923
<i>Dichanthelium xanthophysum</i>	0.2202

TABLE 2. (continued)

Species	Factor
<i>Carex backii</i>	0.2303
<i>Campanula rotundifolia</i>	0.2556
<i>Desmodium canadense</i>	0.2619
<i>Helianthus strumosus</i>	0.2658
<i>Dichanthelium perlongum</i>	0.3389
<i>Dichanthelium villosissimum</i>	0.3724
<i>Carex richardsonii</i>	0.3955
<i>Lupinus perennis</i> ssp. <i>perennis</i> var. <i>perennis</i>	0.4113
<i>Saxifraga virginensis</i>	0.4799
<i>Lespedeza capitata</i>	0.4908
<i>Botrychium multifidum</i>	0.5059
<i>Polygala senega</i>	0.6403
<i>Ceanothus herbaceus</i>	0.6574
<i>Asclepias exaltata</i>	0.6995
<i>Solidago arguta</i> var. <i>arguta</i>	0.7490
<i>Taenidia integerrima</i>	0.7630
<i>Oryzopsis asperifolia</i>	0.7945
<i>Dichanthelium latifolium</i>	0.8177
<i>Solidago bicolor</i>	0.9095
<i>Corylus americana</i>	1.0091
<i>Muhlenbergia glomerata</i>	1.0543
<i>Cirsium discolor</i>	1.2539
<i>Luzula acuminata</i>	1.2578
<i>Desmodium glutinosum</i>	1.3285
<i>Desmodium paniculatum</i> var. <i>paniculatum</i>	1.3992
<i>Ranunculus hispidus</i> var. <i>hispidus</i>	1.6825

using ARCVIEW 3.2 which also allowed for the calculation of areas within polygons. Soil landscapes are areas of soil and land with similar attributes on a broad scale, these attributes including characteristics related to plant growth (Agriculture Canada 1989).

Results and Discussion

(1) Floristic composition

Forty-two remnants were found within an area of approximately 1000 km². These remnants accounted for an area of approximately 250 acres (101.17 hectares, 1.01 km²) and thus represent approximately 0.15–0.33% of the plains area (300–600 km²) previously suggested (Catling et al. 1992); i.e., a fraction of one percent. These had escaped cultivation, excessive grazing, displacement by alien species and destruction by extensive tree planting during the mid-1900s, at which time these sandy areas were considered serious locations of erosion rather than special and restricted natural habitats. The tallgrass and savannah areas evidently were destroyed by nearly complete conversion of the landscape to contiguous small farms with both livestock and crops leaving very little natural habitat. Except on the drier sites, those that escaped agriculture were subject to natural succession to woodland which occurred due to the absence of fire. The remnants are thus probably lacking the more mesic example of prairie. Although native species moved into some abandoned marginal cropland, this recoloniza-

tion was often limited due to the simultaneous invasion of alien species such as Scots Pine and Smooth Brome (Catling and King 2008).

The remnants discovered occurred on steep slopes, roadsides, hydro lines and within two pioneer cemeteries where the soil had not been turned except within local areas, where non-native species had not been introduced, where livestock had been excluded, and where extensive manuring had not occurred as a result of early abandonment. Because trees were excluded to a large extent, these pioneer cemeteries evidently remained as they were since used by the pioneers and represented pristine examples of the natural vegetation. Another significant remnant occurred on the Alderville Reserve where native people have protected the natural landscape and maintained natural processes such as fire. The persistence of prairie relicts in pioneer graveyards and on lands managed by native people is a widespread phenomenon in North America and in many instances it has enabled successful protection of vegetation that would otherwise be gone.

A total of 260 native species was recorded in the remnants but many of these occurred at only one or two of the sites (Figure 2). Sixty-one native species occurred in at least half of the remnants. The most frequent species and those dominating many of the remnants included **Andropogon gerardii*, **Anemone cylindrica*, *Asclepias syriaca*, **Asclepias tuberosa* ssp. *tuberosa*, *Carex pensylvanica*, **Carex siccata*, **Cean-*

othus americanus, *Fragaria virginiana* ssp. *virginiana*, *Maianthemum stellatum*, **Monarda fistulosa* ssp. *fistulosa* var. *fistulosa*, *Poa pratensis* ssp. *pratensis*, *Prunus virginiana* var. *virginiana*, *Pteridium aquilinum* var. *latiusculum*, **Quercus velutina*, *Rhus typhina*, *Solidago juncea*, *Solidago nemoralis* var. *nemoralis*, **Sorghastrum nutans*, *Symphyotrichum oolentangiense* var. *oolentangiense*, *Symphyotrichum urophyllum*, *Symphyotrichum ericoides* var. *ericoides*, and *Toxicodendron rydbergii* (Appendix). Many of these are characteristic dominants of tallgrass prairie and related habitats in the midwest (e.g., Curtis 1959). Eight of them (marked with an asterisk) were recorded from the plains in presettlement times (Catling et al. 1992).

Although the most reliable indication of floristic composition is likely to be that obtained from the early historical records (Catling et al. 1992), these are incomplete and supplementation with additional information from remnants is appropriate provided that the limitations (see also under Methods) are taken into account. A major limitation is the differential response to changing conditions. Some of the species of the plains probably were able to withstand a degree of settlement pressure such as intense grazing and competition with alien plants. *Asclepias syriaca*, for example was very likely a common plant on the plains, and now occurs along roadsides throughout southern Ontario. *Andropogon gerardii* has some capability to spread along roads and railways, especially in the past prior to saturation of the landscape with alien Smooth Brome Grass (*Bromus inermis*). For some other species the situation may have been very different due to increased dependence on stochastic events and biological interactions relating to pollination and dispersal etc. *Lupinus perennis*, known from three remnants (none with more than a few dozen plants), appears to fall into this category and its scarcity today is a contrast to Traill's (1885) observation that "the extensive grassy flats were brilliant with the azure hues of lupine." In most cases, but clearly not all, low frequency in Table 1 probably does reflect low frequency on the former plains landscape.

Of 56 species reported from the plains prior to 1900 (Catling et al. 1992), only 10 were not found in the recent survey. Of these, the Wavy-leaf American Aster (*Symphyotrichum undulatum* (L.) Nesom.) and Running Buffalo Clover (*Trifolium stoloniferum* Muhl. ex Eat.) may have been misidentified since they are far beyond their main native range in the Rice Lake area. Great St. John's-wort (*Hypericum ascyron* L. = *pyramidatum*) is still found in the region, but only in wetland habitats. Thus of 56 species reported prior to 1900, seven species may be extirpated, including the following: Cut-Leaf Grape Fern (*Botrychium dissectum* Spreng. = *obliquum*), Scarlet Indian-Paintbrush (*Castilleja coccinea* (L.) Spreng.), Agueweed (*Gentiana quinquefolia* (L.) Small), Hairy Lettuce (*Lactuca hirsuta* Muhl. ex Nutt.), Virginia Mountain Mint

(*Pycnanthemum virginianum* (L.) T. Dur. & B.D. Jackson ex B.L. Robins. & Fern.), American Wintergreen (*Pyrola americana* Sweet. = *rotundifolia*), and Highbush Blueberry (*Vaccinium corymbosum* L.). Some of these (notably the last two) probably occurred in lower, moist and acid places in savannah. A few small habitats of this kind, dominated by Lowbush Blueberry (*Vaccinium angustifolium*), persist at Alderville (site 12), but none of these species have been found there. As for the others, some of them were characteristic of plains vegetation and occurred elsewhere in Ontario where plains occurred (e.g., *Castilleja coccinea*, *Gentiana quinquefolia*, *Pycnanthemum virginianum*), including the Humber Plains and the Norfolk Plains. Given the loss of the historically recorded species of dry ground, 9.8% (5 of 51) may be extirpated. Extrapolating this percentage to the total dry ground native flora, 28 native species (9.8% of 288 since 260 is 90.2%) of dry ground may be extirpated. However this is to be considered a maximum number since it is difficult to conceive of 28 additional native species of dry ground that likely occurred in the region based on occurrence in areas nearby such as the Trent Valley (Catling and Catling 1993) or former Humber Plains (Varga 1999). Certainly some species are extirpated and frequencies in remnants may not reflect frequency on the original plains. Nevertheless, comparison with original composition and a general knowledge of the usual dominants of these associations suggest that both composition and frequency are much the same, but not exactly the same, as existed in pre-settlement times.

(2) Variation in floristic composition among sites

The PCO analysis explained almost 25% of the variation on the first two axes (Figure 4) which is not unreasonable for ecological data of this kind (Pielou 1984). Variation explained on subsequent axes decreased gradually, with the third axis accounting for 7.2%. The minimum spanning tree helped to resolve three major groupings (Figure 4): (1) sites with open sand on high-elevation neutral sand and characteristic sand barren flora, including *Dichanthelium sabulorum*, *Carex merritt-fernaldii*, *Cyperus lupulinus*, *Polygonum douglasii*, *Selaginella rupestris*, and *Sporobolus cryptandrus* and other species with an ability to grow in either sand or dry grassland such as *Artemisia campestris*, *Liatris cylindracea*, *Linum sulcatum*, and *Ceanothus herbaceus*; (2) prairie sites on neutral to slightly acid pure sand with *Desmodium canadense*, *Monarda fistulosa*, *Penstemon hirsutus*, *Ranunculus rhomboideus*, and *Schizachyrium scoparium* and other species associated mostly with grassland; (3) high-diversity sites with savannah vegetation often on calcareous or neutral gravel, including species characteristic of both prairie and open woodland, including *Asclepias exaltata*, *Desmodium glutinosum*, *Erigeron pulchellus*, *Solidago arguta*, and *Taenidia integerrima* as well as certain rare species such as *Anemone*

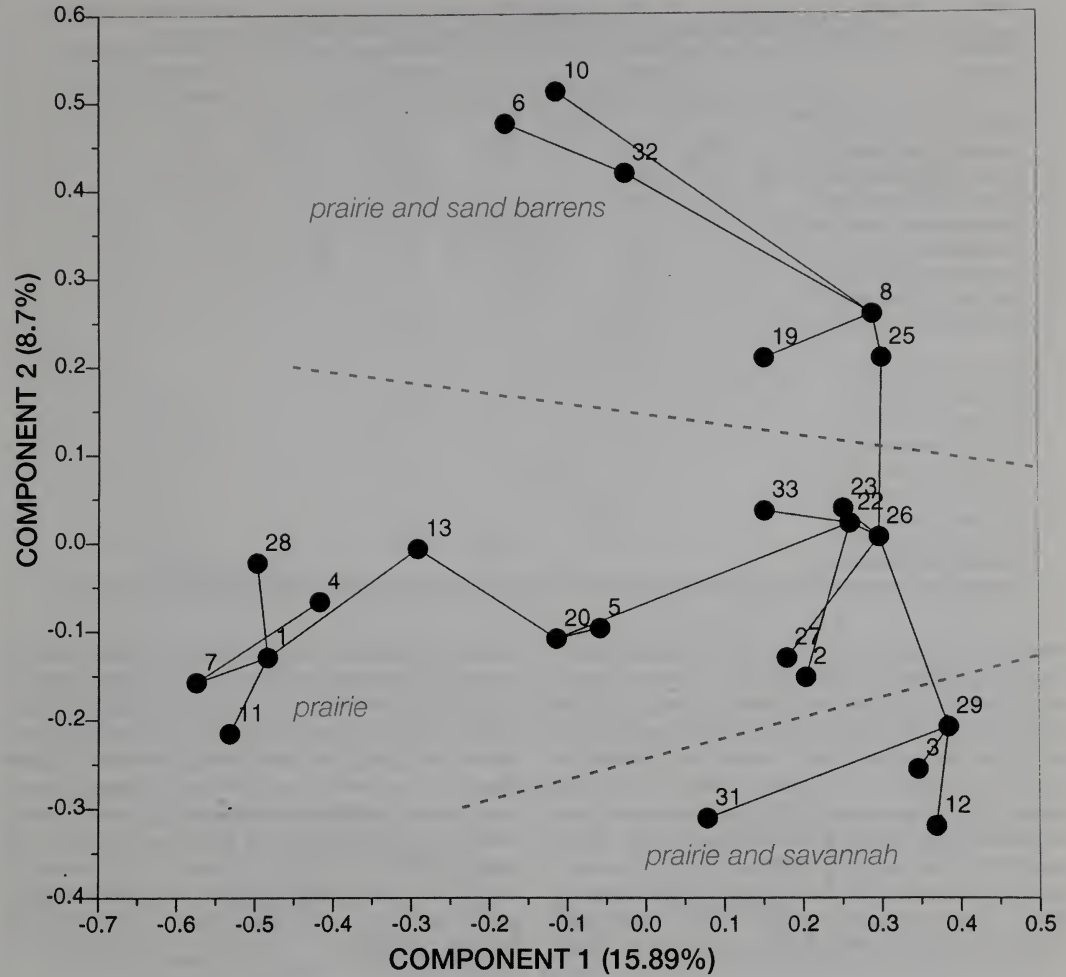


FIGURE 4. Relationships among 24 remnants of Rice Lake Plains vegetation portrayed by Principal Coordinate Analysis based on a matrix of Jaccard's coefficients from species presence/absence data with a superimposed minimum spanning tree. Three groups are suggested, the upper including sand barrens, the middle including prairie and mixed sites and the lower including savannah.

quinquefolia and *Vitis aestivalis*. While a small number of species occur only or predominantly in sand barrens and an equally small number occur only in savannah (Table 3), many species (including those present in the majority of sites (Appendix), are present in all three associations; e.g., *Carex siccata*, *Ceanothus americanus*, and *Andropogon gerardii*. A classification of associations based on sites has limitations because many sites contain more than one association and disturbance and succession may lead to intermediate associations. For example a particular site may have open sand with some characteristic sand barren flora grading into both prairie and savannah. Despite the limitations, the PCO analysis clearly suggests that sites

differ with respect to three major association types (Figure 5).

The first and second dimensions of the CA analysis account for 13.36% and 11.94 % (total 25.3%) of the variation, respectively, with a gradual decline thereafter. The three major site groups revealed by the principal coordinate analysis form a gradation on the first axis with the sand barren group on the left, the prairie in the centre, and the savannah on the right (Figure 6). The fact that the sites are not discrete but form a continuum on this axis, which accounts for most of the variation, suggests that they intergrade. Field observations over a decade suggest that this intergradation may be a result of a succession from sand barren to

TABLE 3. Exemplary indicator species for group 1 (sand barrens and prairie) and group 3 (savannah and prairie) associations (see Figure 4) with percentages of their overall occurrence within particular associations.

Species	Group 1 Sand Barren (6)	Group 2 Prairie/Mixed (14)	Group 3 Savannah (4)
GROUP 1 INDICATORS			
<i>Artemisia campestris</i> (10)	50.0	50.0	—
<i>Carex merritt-fernaldii</i> (10)	100.0	38.1	25.0
<i>Cyperus lupulinus</i> (10)	100.0	38.1	—
<i>Dichanthelium sabulorum</i> (5)	50	14.3	—
<i>Linum sulcatum</i> (7)	50.0	28.6	—
<i>Polygonum douglasii</i> (2)	33.3	—	—
<i>Selaginella rupestris</i> (4)	50.0	7.1	—
<i>Sporobolus cryptandrus</i> (7)	50.0	28.6	—
GROUP 2 INDICATORS			
<i>Asclepias exaltata</i> (5)	—	14.2	75.0
<i>Cirsium discolor</i> (3)	—	7.1	50.0
<i>Corylus americana</i> (5)	—	7.1	100.0
<i>Desmodium glutinosum</i> (4)	—	7.1	75.0
<i>Erigeron pulchellus</i> (5)	—	14.2	75.0
<i>Saxifraga virginiensis</i> (3)	—	—	75.0
<i>Solidago arguta</i> (4)	—	7.1	75.0
<i>Taenidia integerrima</i> (4)	—	—	100.0

prairie to savannah to woodland with increasing organic matter accumulation and increasing tree colonization. The rate of succession almost certainly depends upon soil moisture and would have been mediated by fire in pre-settlement times. Natural fires burned on parts of the plains every summer (Roche 1845*). Fires burning in different areas at different frequencies and in different sites ranging from mesic to very dry would have led to associations in different stages of succession. In some cases, succession was likely arrested by fire; i.e., prairie with oak “grubs” which would rapidly become savannah with the cessation of fire. Wide-

spread topographic variation likely would have led to a mosaic of associations. Thus, it seems likely that substantial variation in associations often existed within smaller areas of 1 km² but at the same time. Sand barrens would likely have been most prevalent at higher elevations on coarse sand, whereas savannah would have prevailed at lower elevations on gravelly soils. Since some of the hills and slopes are gravelly and partly protected from heat exposure (north slopes) it seems most likely that savannah and open woodland developed on hills with sand barrens and prairie on the land between.

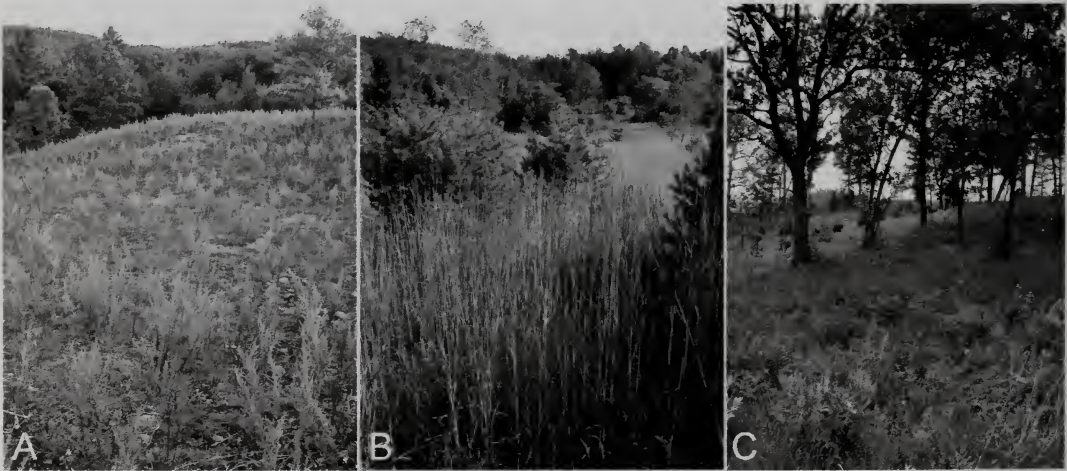


FIGURE 5. Examples of major associations represented by remnants of the Rice Lake Plains. A, sand barren, this one dominated by *Artemisia campestris* ssp. *borealis* (site 10); B, prairie dominated by Big Bluestem (*Andropogon gerardii*) (site 10); C, savannah with Black Oaks (*Quercus velutina*) at Alderville (site 12).

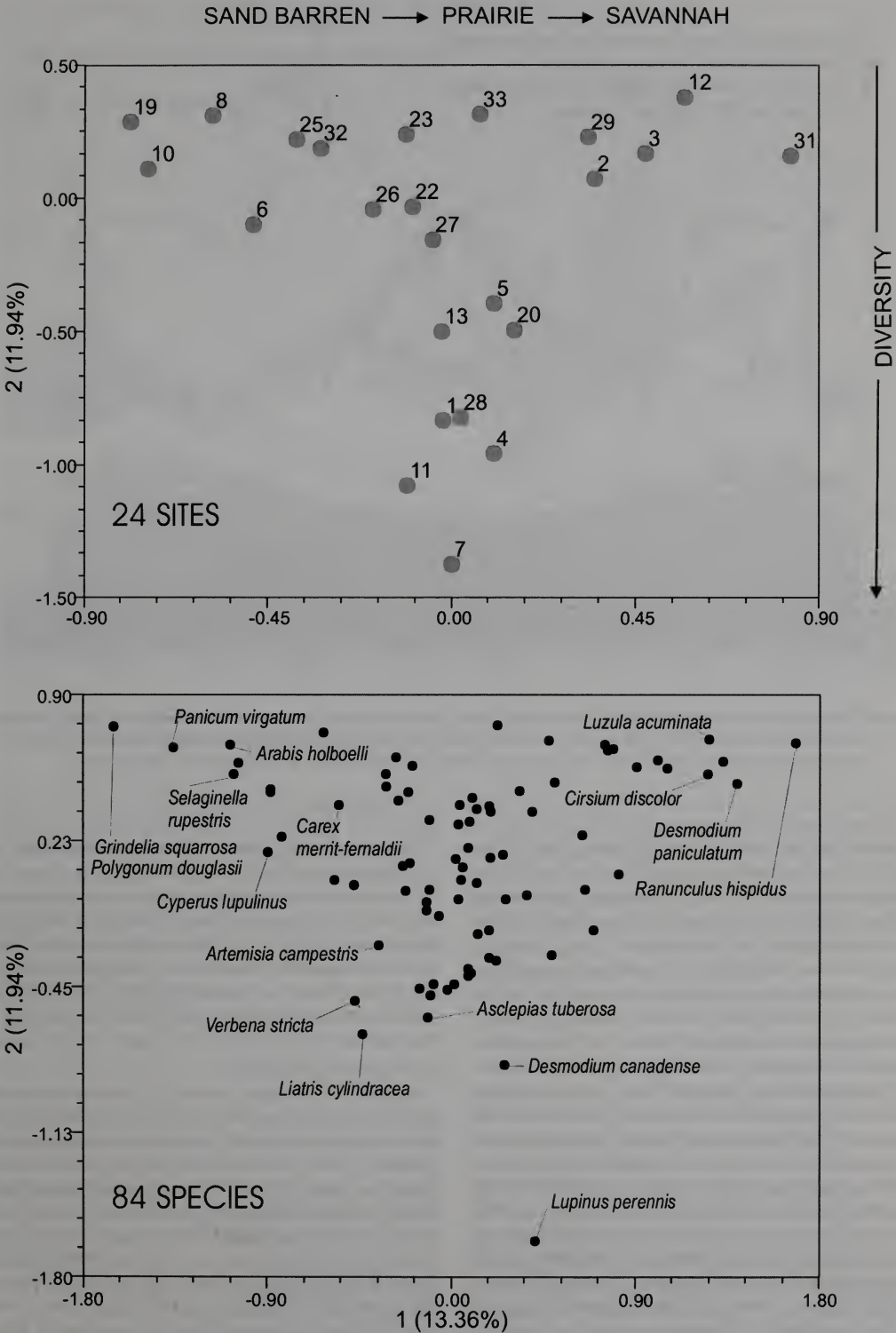


FIGURE 6. Correspondance analysis with a plot of dimensions 1 and 2 by site (above) and by species (below).

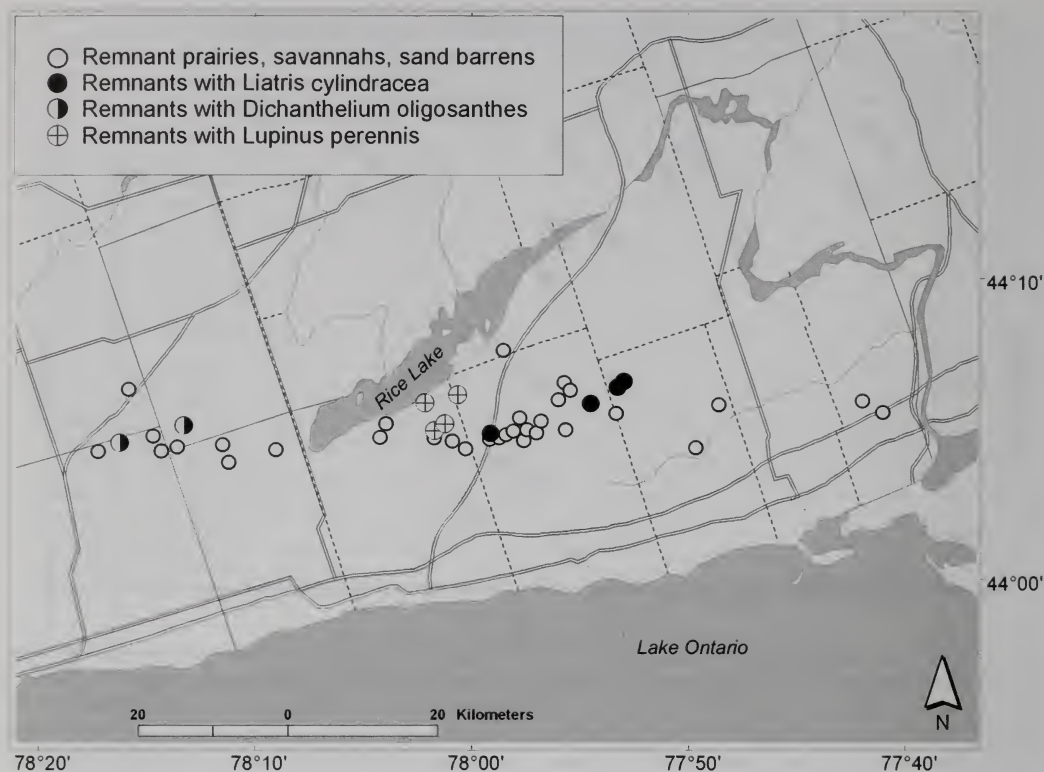


FIGURE 7. Rice Lake Plains region showing the locations of 42 remnant sites (circles) with the locations for certain regionally rare species shown. Regional floristic variation within the plains is suggested by the occurrences of *Dichanthelium oligosanthes* (half-dots), *Liatris cylindracea* (filled dots), and *Lupinus perennis* (circles with crosses).

Species are associated with different parts of the gradation on the first dimension (Figure 6 lower). For example a number of species unique to sand barrens appear on the left-hand side and other species unique to savannah appear on the extreme right. An indication of the association of species with either sand barren, prairie/mixed, or savannah associations can be obtained by a listing of species in ascending order of row factors on dimension 1 (Table 2). The species at the top of the list are exclusively or primarily associated with sand barren whereas those at the bottom of the list are primarily or exclusively associated with savannah. Species associated mainly with prairie and mixed associations are in the middle of the list.

The second axis in the CA plot is related to diversity, with the lower diversity sites at the bottom of the plot (Figure 6 upper). Some of these lower diversity sites are disturbed edges of roads and fields, and the species associated with the lower diversity sites, including *Asclepias tuberosa*, *Desmodium canadense*, *Liatris cylindracea*, *Lupinus perennis* and *Verbena stricta*, are species that may benefit from disturbance to the soil.

Most of the variation in floristic composition between sites is related to a succession from open sand to woodland with at least three species groups, and secondarily, to diversity possibly related to soil disturbance history. However, there is some regional variation that was not revealed in these analyses. For example *Dichanthelium oligosanthes*, *Liatris cylindracea* and *Lupinus perennis* all are restricted to a portion of the plains area (Figure 7).

(3) Extent of occurrence

Prairies, savannahs and sand barrens occurred throughout a huge area of western North America in pre-settlement times but the presence of these habitats further east is less well known. Judging by the distribution of relict vegetation, they extended narrowly eastward in the southern Great Lakes (Catling and McKay 1974; Roberts et al. 1977; Bakowsky and Riley 1994; Faber-Langendoen and Maycock 1994; Goodban et al. 1996; Rodger 1998; Varga 1999, 2001*). On the north side of Lake Ontario the eastern limit was evidently the Trent River (Catling and Catling 1993; Catling and Brownell 1999), although sandy open habitats with some unusual species occur in eastern

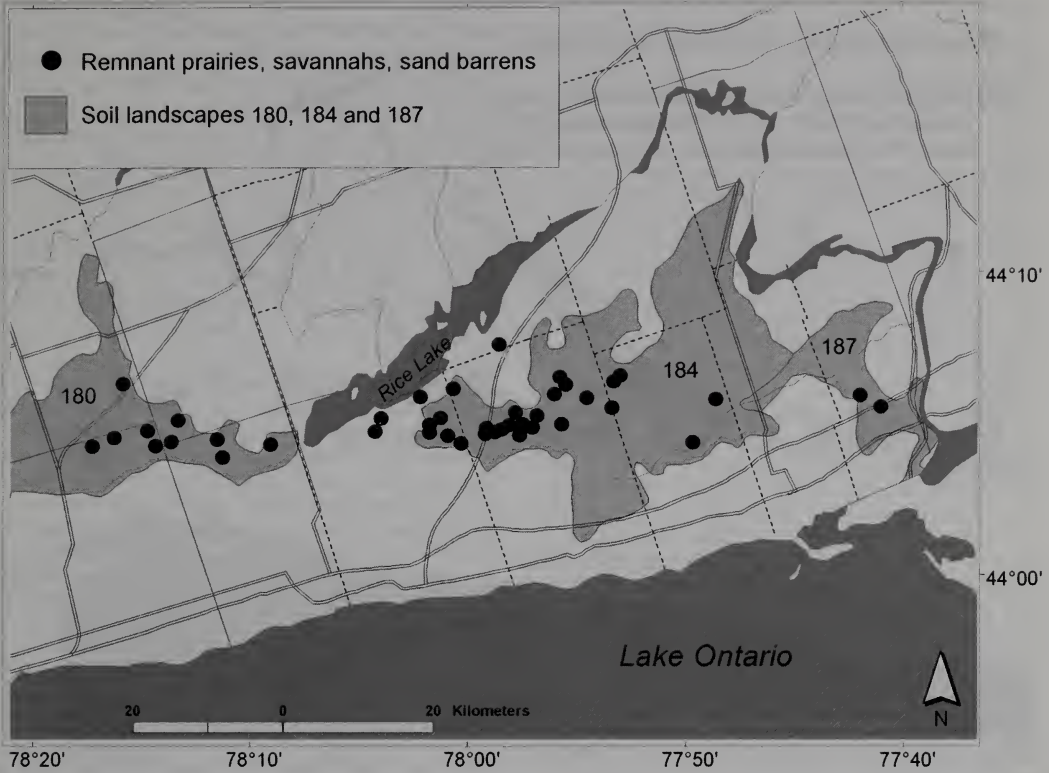


FIGURE 8. Rice Lake Plains region showing the locations of 42 remnant sites with soil landscapes superimposed. Soil landscape data from Agriculture Canada (1989).

Ontario; however, these are sand barrens rather than savannah or prairie (Carbyn and Catling 1995). On the south side of Lake Ontario the prairies, savannahs and sand barrens may have existed more or less continuously east to the Mohawk and Hudson valleys (e.g., Day 1953; Marks et al. 1992). The continuity of these habitats may have been substantial during the warmer and drier hypsithermal (xerothermic) interval (Deevey and Flint 1957) 5000 years ago, but subsequent forest expansion left these habitats as more or less disconnected islands. Many species with largely western distributions apparently moved narrowly eastward along this more or less continuous corridor, resulting in a characteristic distribution pattern, but some did not reach as far as the coastal plain while others radiated onto its northern section. The Rice Lake Plains and smaller areas in the valley of the Trent River on its eastern border (Catling and Catling 1993) appear to represent the northeastern limit of prairie and sand barren in North America.

In the Rice Lake area, dry open habitats with native vegetation exist primarily within three soil landscapes (units 180, 184 and 187, Agriculture Canada 1989) and are widely distributed within these landscapes. All of these landscapes have relict Black Oaks (*Quercus*

velutina) along field edges and tree lines, and these oaks are extensively distributed throughout. Since these oaks often are associated with savannah and prairie vegetation, their occurrence supports the idea that these kinds of vegetation were predominant throughout the region. Only four of 42 sites are not within these landscapes (Figure 8). Three are in 182 (to the west of 184) and the northernmost is in 185. Both of these landscapes are extensive and have only localized relict Black Oak, which makes it seem unlikely that they contained extensive dry, open habitats. Consequently, these landscapes are excluded from the calculation of the plains area. Since remnants are known only from the eastern half of the Ganaraska Highland (in 180), only this eastern half, approximately 150 km², is considered likely to have been plains. All but the southern lobe of landscape 184 (the central landscape—see also Methods) seems likely to have been plains, although the remaining area includes some wetlands. Removing the wetlands and the southern lobe leaves approximately 360 km². The upper portion of landscape 187 (the part shown in Figure 8) is approximately 80 km². Therefore, collectively based on the landscape analysis the plains likely occupied a band from the Ganaraska Highland east to the Trent River, including approxi-

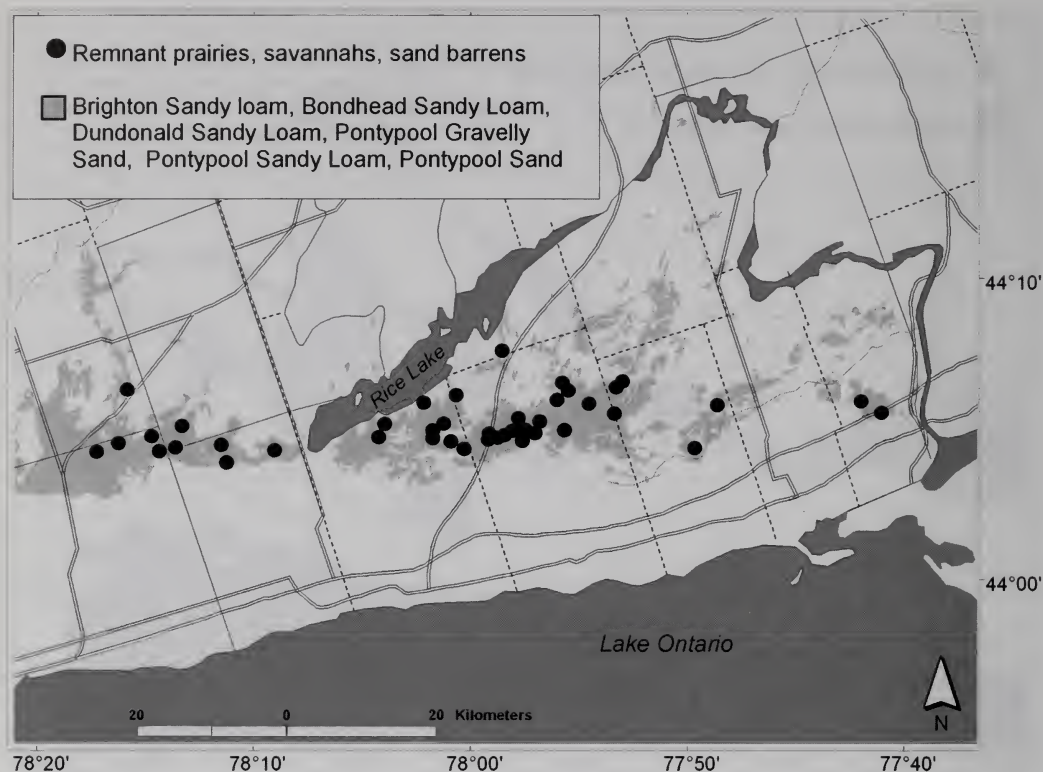


FIGURE 9. Rice Lake Plains region showing the locations of 42 remnant sites with the extent of coarse sandy soil types delineated. Soil landscape data from Webber et al. (1946) and Hoffman and Acton (1974).

approximately 590 km² (approximately 59 000 hectares, approximately 145 792 acres, Figure 8).

With respect to soils, most of the remnants occur principally on the extensive Pontypool Sand (Table 1). The eastern area of Pontypool Sand in Durham (much of the Ganaraska Highland where remnants occur on the west side of Rice Lake) includes approximately 101 km² (Webber et al. 1946). The area of this soil type south and east of Rice Lake and north of the height of land between Rice Lake and Lake Ontario is also approximately 101 km². To this can be added approximately 61 km² of other sandy soil types, north of the height of land, which are represented by remnants. All of this area (Figure 9), representing the soil types conducive to prairie, savannah and sand barren development, existed over an approximate area of 263 km² on the east, south, and west sides of Rice Lake. The extensive occurrence of remnants throughout this region suggests that all of these soils may have been occupied by plains vegetation including prairie, savannah and sand barren. This area of open habitat, 263 km² approx. (65 000 acres, approximately 26 305 hectares), is considered very conservative since frequent fire may have allowed open habitat on adjacent soils and at lower elevations where prairie remnants

were less likely to survive due to less extreme conditions (such as the southwest corner of Rice Lake where the early explorers reported plains (Hambly 1795*; Fothergill 1817*; Catling et al. 1992).

The area of 263–590 km² is a more extensive area of prairie, savannah and sand barren than that suggested earlier (Catling et al. 1992) based on: (1) early surveys which were incomplete but nevertheless indicated a definite area of 172.2 km²; and (2) on a general consideration of soil and elevation which resulted in an estimate of 250–300 km². This earlier estimate did not take into account the area west of Rice Lake because, apart from Roche's (1845*) reference to plains in the 9th and 10th concessions of Hope Township, the plains area in that region was thought to be small and isolated. The distribution of remnants in relation to soil and landscape was not used in the earlier analysis. Based on current information, including that presented here, the Rice Lake Plains included an area of prairie, savannah and sand barrens approximately 600 km² in extent and extending as an essentially continuous band 123 km long and up to 25 km wide along the top and north slope of the Oak Ridges Moraine from the Ganaraska Highland west of Rice Lake eastward to the Murray Hills and the Trent River.

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APPENDIX. Species of vascular plants found in 24 remnants of Rice Lake plains vegetation arranged in descending order of frequency (number of 24 potential sites where present). Within frequency categories the species are arranged alphabetically by scientific name. Species marked with an asterisk (*) are regionally rare based on personal observations and Varga (2001*). Of the 42 remnants known, the 24 included here have reasonably complete species lists. Three species at the end of the list are not known from the well-inventoried sites, but occur in the western Ganaraska section (White 2003*). Scientific and common names are taken largely from Kartesz and Meachum (1999).

Sites	Scientific/Common Name
24	<i>Asclepias syriaca</i> L. / COMMON MILKWEED / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,31,32,33
"	* <i>Carex siccata</i> Dewey / DRY-SPIKE SEDGE / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,31,32,33
23	<i>Anemone cylindrica</i> Gray / LONG-HEAD THIMBLEWEED / 1,2,3,4,5,6,7,8,10,11,12,13,20,22,23,25,26,27,28,29,31,32,33
"	<i>Fragaria virginiana</i> Duchesne ssp. <i>virginiana</i> / VIRGINIA STRAWBERRY / 1,2,3,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,31,32,33
"	<i>Maianthemum stellatum</i> (L.) Link (<i>Smilacina stellata</i>) / STARRY FALSE SOLOMON'S-SEAL / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,31,32
"	<i>Pteridium aquilinum</i> L. Kuhn var. <i>latiusculum</i> (Desv.) Underwood ex Heller / NORTHERN BRACKEN FERN / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,29,31,32,33
"	* <i>Quercus velutina</i> Lam. / BLACK OAK / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,31,32
"	<i>Solidago nemoralis</i> Ait. var. <i>nemoralis</i> / GRAY GOLDENROD / 1,2,3,4,5,6,7,8,11,12,13,19,20,22,23,25,26,27,28,29,31,32,33
"	<i>Symphytotrichum oolentangiense</i> (Riddell) Nesom var. <i>oolentangiense</i> / SKY-BLUE AMERICAN-ASTER / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,32,33
22	<i>Poa pratensis</i> L. ssp. <i>pratensis</i> / KENTUCKY BLUE GRASS / 1,2,3,4,5,6,7,8,10,11,13,19,20,22,23,25,26,28,29,31,32,33
"	<i>Prunus virginiana</i> L. var. <i>virginiana</i> / CHOKE CHERRY / 1,2,3,4,6,7,10,11,12,13,19,20,22,23,25,26,27,28,29,31,32,33
"	<i>Toxicodendron rydbergii</i> (Small ex Rydb.) Greene / POISON IVY / 1,2,3,4,5,6,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,32
21	* <i>Asclepias tuberosa</i> L. ssp. <i>tuberosa</i> / BUTTERFLY MILKWEED / 1,2,3,4,5,6,7,8,10,11,12,13,20,22,23,25,26,27,28,29,32
"	* <i>Ceanothus americanus</i> L. / NEW JERSEY-TEA / 1,2,3,4,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,32,33
"	* <i>Monarda fistulosa</i> L. ssp. <i>fistulosa</i> var. <i>fistulosa</i> / OSWEGO / 1,2,3,4,7,8,10,11,12,13,19,20,22,23,25,26,27,28,29,31,33
"	* <i>Sorghastrum nutans</i> (L.) Nash / YELLOW INDIAN GRASS / 1,2,3,4,5,6,7,8,11,12,13,19,20,22,23,25,26,27,29,31,33
20	* <i>Andropogon gerardii</i> Vitman / BIG BLUESTEM / 1,2,3,4,5,8,10,11,12,13,20,22,23,25,26,27,28,29,31,33
"	<i>Carex pensylvanica</i> Lam. / PENNSYLVANIA SEDGE / 1,2,3,4,5,6,7,8,10,12,13,19,20,22,23,25,28,29,31,32
"	<i>Rhus typhina</i> L. / STAG-HORN SUMAC / 1,2,3,4,5,6,7,10,12,13,19,20,22,23,25,26,29,31,32,33
"	<i>Solidago juncea</i> Ait. / EARLY GOLDENROD / 1,2,3,5,6,7,8,11,12,13,19,20,22,23,25,26,27,29,31,32
"	<i>Symphytotrichum ericoides</i> var. <i>ericoides</i> / WHITE HEALTH AMERICAN-ASTER / 1,2,3,5,6,7,8,12,19,20,22,23,25,26,27,28,29,31,32,33
"	<i>Symphytotrichum urophyllum</i> (Lindl.) Nesom / WHITE ARROW AMERICAN-ASTER / 1,2,3,5,6,7,8,12,13,19,20,22,23,25,26,27,29,31,32,33
19	* <i>Amelanchier stolonifera</i> Wieg. / RUNNING SERVICE-BERRY / 1,2,3,5,8,10,12,13,19,20,22,23,25,26,27,28,29,31,32
"	* <i>Calystegia spithamea</i> (L.) Pursh ssp. <i>spithamea</i> / LOW FALSE BINDWEED / 1,2,3,5,6,8,10,12,13,19,20,22,23,25,26,27,29,32,33
"	<i>Pinus strobus</i> L. / EASTERN WHITE PINE / 1,2,3,4,5,10,11,12,13,19,20,22,23,25,26,29,31,32,33
"	<i>Vitis riparia</i> Michx. / RIVER-BANK GRAPE / 1,2,3,4,5,7,8,10,11,12,13,20,22,23,25,26,28,29,32
18	<i>Apocynum androsaemifolium</i> L. / SPREADING DOGBANE / 1,2,3,5,6,8,12,19,20,22,23,25,26,27,28,29,31,32
"	<i>Danthonia spicata</i> (L.) Beauv. ex Roemer & J.A. Schultes / POVERTY WILD OAT GRASS / 1,2,5,6,8,10,12,13,19,22,23,25,26,27,29,31,32,33
"	* <i>Elymus trachycaulus</i> (Link) Gould ex Shinners ssp. <i>subsecundus</i> (Link) A. & D. Löve (includes unilaterale) / SLENDER WILD RYE / 1,2,3,8,12,13,19,20,22,23,25,26,27,28,29,31,32,33
18	* <i>Potentilla arguta</i> Pursh ssp. <i>arguta</i> / TALL CINQUEFOIL / 2,3,4,5,7,8,12,13,19,20,22,23,25,26,27,28,29,31
"	<i>Quercus rubra</i> L. var. <i>rubra</i> / NORTHERN RED OAK / 2,3,4,5,7,8,10,11,12,13,19,20,22,23,25,29,31,32

APPENDIX. (continued)

Sites	Scientific/Common Name
18	<i>Solidago canadensis</i> L. var. <i>canadensis</i> / CANADIAN GOLDENROD / 2,3,4,5,7,8,11,12,13,19,20,22,23,25,28,29,31,32
17	* <i>Carex muehlenbergii</i> Schkuhr ex Willd. var. <i>muehlenbergii</i> / MUHLENBERG'S SEDGE / 2,3,4,6,8,10,12,19,20,22,23,25,26,27,29,32,33
"	* <i>Helianthus divaricatus</i> L. / WOODLAND SUNFLOWER / 1,2,3,5,8,11,12,13,19,20,22,23,26,27,29,31,33
"	<i>Salix humilis</i> Marsh. var. <i>humilis</i> / PRAIRIE WILLOW / 2,3,8,10,11,12,19,20,22,23,25,26,27,28,29,31,33
16	<i>Aquilegia canadensis</i> L. / RED COLUMBINE / 2,3,5,7,11,12,13,19,20,22,23,25,27,29,31,32
"	* <i>Juniperus communis</i> L. var. <i>depressa</i> Pursh / COMMON JUNIPER / 1,2,3,5,6,7,8,19,22,23,25,26,29,31,32,33
"	<i>Populus tremuloides</i> Michx. / QUAKING ASPEN / 1,2,3,4,7,8,10,12,19,22,23,25,26,29,31,32
"	* <i>Rosa acicularis</i> Lindl. ssp. <i>acicularis</i> / PRICKLY ROSE / 2,3,6,8,10,13,20,22,23,25,26,28,29,31,32,33
"	* <i>Rosa blanda</i> Ait. var. <i>blanda</i> / SMOOTH ROSE / 1,2,6,7,11,12,20,22,23,25,26,27,29,31,32,33
"	<i>Rubus allegheniensis</i> Porter var. <i>allegheniensis</i> / ALLEGHENY BLACKBERRY / 2,3,6,7,8,10,12,19,20,22,23,26,27,29,31,32
15	* <i>Comandra umbellata</i> (L.) Nutt ssp. <i>umbellata</i> / BASTARD-TOADFLAX / 2,3,5,8,10,12,13,20,22,23,25,26,29,31,32
"	* <i>Dichanthelium acuminatum</i> (Sw.) Gould & C.A. Clark var. <i>acuminatum</i> (<i>D. implicatum</i>) / TAPERED ROSETTE GRASS / 1,2,3,5,8,12,19,20,22,25,26,27,29,31,33
"	* <i>Penstemon hirsutus</i> (L.) Willd. / HAIRY BEARDTONGUE / 2,3,5,6,8,12,19,20,22,23,25,26,27,29,31
"	<i>Quercus alba</i> L. / NORTHERN WHITE OAK / 2,3,5,7,8,12,13,19,20,22,23,25,29,31,32
14	* <i>Carex tonsa</i> (Fern.) Bickn. var. <i>rugosperma</i> (Mackenzie) Crins / SHAVED SEDGE / 2,3,5,8,12,19,22,23,25,26,27,29,32,33
"	* <i>Comptonia peregrina</i> (L.) Coult. / SWEET-FERN / 3,6,8,10,19,20,22,23,25,26,27,28,29,32
"	<i>Cornus racemosa</i> Lam. / GRAY DOGWOOD / 2,5,6,7,13,19,20,22,23,25,26,28,29,31
"	* <i>Desmodium canadense</i> (L.) DC. / SHOWY TICK-TREFOIL / 1,3,5,7,8,11,12,13,20,26,27,28,29,31
"	* <i>Lilium philadelphicum</i> L. var. <i>philadelphicum</i> / WOOD LILY / 2,3,4,11,12,19,20,22,23,25,26,27,29,31
"	<i>Maianthemum canadense</i> Desf. / FALSE LILY-OF-THE-VALLEY / 2,3,5,7,8,11,12,13,20,22,25,29,31,32
"	<i>Maianthemum racemosum</i> (L.) Link ssp. <i>racemosum</i> (<i>Smilacina racemosa</i>) / FALSE SOLOMAN'S SEAL / 2,3,5,7,11,12,13,19,20,22,25,28,29,31
"	* <i>Ranunculus rhomboideus</i> Goldie / LABRADOR BUTTERCUP / 2,3,4,5,6,8,12,19,20,25,26,27,29,32
"	* <i>Schizachyrium scoparium</i> (Michx.) Nash var. <i>scoparium</i> / LITTLE FALSE BLUESTEM / 2,3,5,8,12,19,22,23,25,26,27,29,31,33
13	* <i>Bromus kalmii</i> Gray / KALM'S BROME / 3,5,8,12,13,20,22,23,25,26,27,29,33
"	<i>Rudbeckia hirta</i> L. var. <i>hirta</i> / BLACK-EYED-SUSAN / 2,3,5,8,12,19,20,25,27,29,31,32,33
12	<i>Cornus rugosa</i> Lam. / ROUND-LEAF DOGWOOD / 1,2,5,7,12,13,20,22,23,26,29,31
"	* <i>Lechea intermedia</i> Leggett ex Britt. var. <i>intermedia</i> / ROUND-FRUIT PINWEED / 2,3,8,10,12,19,23,25,26,27,29,33
"	* <i>Polygala polygama</i> Walt. / RACEMED MILKWORT / 2,3,4,8,10,12,19,22,25,26,27,29
"	* <i>Potentilla simplex</i> Michx. / OLD-FIELD CINQUEFOIL / 2,3,5,6,8,12,20,22,25,29,31,32
"	<i>Symphoricarpos albus</i> (L.) Blake var. <i>albus</i> / COMMON SNOWBERRY / 3,5,6,8,12,13,19,23,29,31,32,33
11	<i>Antennaria howellii</i> Greene ssp. <i>petaloidea</i> (Fern.) Bayer / SMALL PUSSYTOES / 2,3,5,8,12,19,22,23,25,27,31
"	* <i>Campanula rotundifolia</i> L. / BLUEBELL-OF-SCOTLAND / 3,5,8,12,20,22,23,26,29,31,32
"	* <i>Carex merriitt-fernaldii</i> Mackenzie / MERRITT FERNALD'S SEDGE / 3,6,8,10,19,22,23,25,26,29,33
"	* <i>Carex richardsonii</i> R. Br. / RICHARDSON'S SEDGE / 2,3,12,22,23,25,26,27,29,31,33
"	* <i>Vaccinium angustifolium</i> Ait. / LATE LOWBUSH BLUEBERRY / 2,3,8,10,12,13,23,29,31,32,33
"	* <i>Viola adunca</i> Sm. var. <i>adunca</i> / HOOK-SPUR VIOLET / 2,3,5,8,12,19,23,25,29,31,32
10	* <i>Arctostaphylos uva-ursi</i> (L.) Spreng. / RED BEARBERRY / 2,3,8,12,22,25,26,27,29,33
"	* <i>Artemisia campestris</i> L. ssp. <i>borealis</i> (Pallas) Hall & Clements var. <i>scouleriana</i> (Hook.) Cronq. / PACIFIC WORMWOOD / 8,10,11,12,13,19,20,23,25,26,27
"	* <i>Cyperus lupulinus</i> (Spreng.) Marcks. ssp. <i>lupulinus</i> / GREAT PLAINS FLAT SEDGE / 6,8,10,13,19,22,23,25,26,32
"	* <i>Helianthus strumosus</i> L. / PALE-LEAF WOODLAND SUNFLOWER / 3,11,12,19,23,26,28,29,31,33
"	* <i>Lespedeza capitata</i> Michx. / ROUND-HEAD BUSH-CLOVER / 2,3,4,6,12,20,28,29,31,32
"	* <i>Prunus pumila</i> L. var. <i>susquehanae</i> (hort. ex Willd.) Jaeger / SUSQUEHANA SAND CHERRY / 2,3,10,12,22,23,25,26,27,29
"	* <i>Rhus aromatica</i> Ait. var. <i>aromatica</i> / FRAGRANT SUMAC / 8,12,13,22,23,26,27,29,31,32
9	<i>Crataegus douglasii</i> Lindl. var. <i>douglasii</i> / BLACK HAWTHORN / 2,3,6,7,8,19,25,28,29
"	* <i>Dichanthelium villosissimum</i> (Nash) Freckmann var. <i>praecocius</i> (A.S. Hitchc. & Chase) Freckmann / WHITE-HAIR ROSETTE ROCK / 2,3,4,12,22,23,26,27,29
"	* <i>Juniperus virginiana</i> L. var. <i>virginiana</i> / EASTERN RED-CEDAR / 3,8,12,22,26,27,31,32,33
"	* <i>Pinus resinosa</i> Ait. / RED PINE / 3,5,7,12,19,20,23,27,29
"	<i>Rubus idaeus</i> L. ssp. <i>idaeus</i> / COMMON RED RASPBERRY / 2,3,12,22,25,27,29,31,33
"	* <i>Shepherdia canadensis</i> (L.) Nutt. / RUSSET BUFFALO-BERRY / 8,12,19,22,23,25,26,29,33
"	* <i>Viola sagitta</i> Ait. var. <i>ovata</i> (Nutt.) Torr. & Gray / ARROW-LEAF VIOLET / 3,8,12,22,25,26,27,29,33
8	<i>Achillea millefolium</i> L. var. <i>occidentalis</i> DC. (<i>A. lanulosa</i>) / SMALL PUSSYTOES / 2,3,5,8,12,19,20,33
"	<i>Anaphalis margaritacea</i> (L.) Benth. / PEARLY-EVERLASTING / 2,3,6,8,10,12,19,32

APPENDIX. (continued)

Sites	Scientific/Common Name
8	<i>Antennaria parlinii</i> Fern. ssp. <i>fallax</i> (Greene) Bayer & Stebbins / PARLIN'S PUSSYTOES / 2,3,12,22,23,25,31,33
"	* <i>Dichanthelium depauperatum</i> (Muhl.) Gould / STARVED ROSETTE GRASS / 2,8,12,19,22,25,26,33
"	* <i>Helianthemum canadense</i> (L.) Michx. / LONG-BRANCH FROSTWEED / 3,8,10,19,27,29,31,32
7	<i>Amelanchier arborea</i> (Michx. f.) Fern. var. <i>arborea</i> / DOWNY SERVICE-BERRY / 3,5,12,20,25,29,31
"	<i>Corylus cornuta</i> Marsh. var. <i>cornuta</i> / BEAKED HAZELNUT / 2,3,12,22,23,29,31
"	<i>Eurybia macrophylla</i> (L.) Cass. (<i>Aster macrophyllus</i>) / LARGE-LEAF WOOD-ASTER / 2,3,12,20,22,29,31
"	<i>Euthamia graminifolia</i> (L.) Greene var. <i>graminifolia</i> / FLAT-TOP GOLDENTOP / 2,5,11,12,22,28,31
"	* <i>Linum sulcatum</i> Riddell var. <i>sulcatum</i> / GROOVED YELLOW FLAX / 5,6,8,19,26,27,29
"	<i>Populus grandidentata</i> Michx. / BIG-TOOTH ASPEN / 2,3,8,12,29,31,32
"	<i>Symphyotrichum novae-angliae</i> (L.) Nesom / NEW ENGLAND AMERICAN-ASTER / 2,3,5,12,25,29,31
"	* <i>Verbena stricta</i> Vent. / HOARY VERVAIN / 7,8,11,19,22,23,29
"	* <i>Sporobolus cryptandrus</i> (Torr.) Gray / SAND DROPSEED / 6,8,10,23,25,32,33
6	* <i>Dichanthelium perlongum</i> (Nash) Freckmann / ELONGATE PANIC GRASS / 3,12,23,25,27,29
"	<i>Diervilla lonicera</i> P. Mill. / NORTHERN BUSH HONEYSUCKLE / 2,8,12,19,23,29
"	* <i>Helianthemum bicknellii</i> Fern. / HOARY FROSTWEED / 6,8,12,25,29,33
"	* <i>Muhlenbergia glomerata</i> (Willd.) Trin. / SPIKED MUHLY / 2,3,12,29,31,33
"	* <i>Polygala senega</i> L. / SENECA-SNAKEROOT / 2,3,12,13,23,29
"	<i>Smilax herbacea</i> L. / SMOOTH CARRION-FLOWER / 3,10,12,29,31,33
"	<i>Solidago gigantea</i> Ait. / LATE GOLDENROD / 8,11,12,19,25,29
"	<i>Thalictrum dioicum</i> L. / EARLY MEADOW-RUE / 2,3,5,12,29,31
"	<i>Amelanchier laevis</i> Wieg. / ALLEGHENY SERVICE-BERRY / 2,3,23,25,29,31
"	<i>Physalis heterophylla</i> Nees / CLAMMY GROUND-CHERRY / 5,6,8,10,23,25
5	<i>Acer saccharum</i> Marsh. var. <i>saccharum</i> / SUGAR MAPLE / 2,3,12,29,31
"	<i>Ambrosia artemisiifolia</i> L. var. <i>artemisiifolia</i> / ANNUAL RAGWEED / 3,12,19,27,32
"	* <i>Arabis divaricata</i> A. Nels. (pro sp.) / HYBRID ROCK CRESS / 8,12,19,23,25
"	<i>Bromus pubescens</i> Muhl. ex Willd. / HAIRY WOODLAND BROME / 3,12,13,20,29
"	* <i>Corylus americana</i> Walt. / AMERICAN HAZELNUT / 3,12,23,29,31
"	* <i>Dichanthelium latifolium</i> (L.) Gould & C.A. Clark / BROAD-LEAF ROSETTE GRASS / 2,3,20,23,31
"	* <i>Dichanthelium linearifolium</i> (Scribn. ex Nash) Gould / SLIM-LEAF ROSETTE GRASS / 8,10,19,25,29
"	* <i>Dichanthelium sabulorum</i> (Lam.) Gould & C.A. Clark var. <i>thinium</i> (A.S. Hitchc. & Chase) Gould & C.A. Clark (<i>D. columbianum</i>) / HEMLOCK ROSETTE GRASS / 5,8,10,23,25
"	* <i>Dichanthelium xanthophyllum</i> (Gray) Freckmann / SLENDER ROSETTE GRASS / 2,13,20,22,33
"	* <i>Erigeron pulchellus</i> Michx. var. <i>pulchellus</i> / ROBIN'S-PLANTAIN / 3,12,22,23,29
"	<i>Galium circaeans</i> Michx. / LICORICE BEDSTEAW / 2,3,12,29,31
"	<i>Prunella vulgaris</i> L. ssp. <i>vulgaris</i> / COMMON SELFHEAL / 1,2,3,12,29
"	<i>Schizachne purpurascens</i> (Torr.) Swallen / FALSE MELIC GRASS / 1,3,12,29,31
"	<i>Silene antirrhina</i> L. / SLEEPY CATCHFLY / 10,12,19,29,32
"	* <i>Solidago bicolor</i> L. / WHITE GOLDENROD / 3,12,29,31,32
"	<i>Prunus serotina</i> Ehrh. / BLACK CHERRY / 3,12,19,25,29
"	<i>Sisyrinchium montanum</i> Greene var. <i>montanum</i> / STRICT BLUE-EYED-GRASS / 2,3,12,27,29
4	<i>Agrimonia gryposepala</i> Wallr. / TALL HAIRY GROOVEBURR / 3,12,29,31
"	<i>Amelanchier sanguinea</i> (Pursh) DC. var. <i>sanguinea</i> / ROUND-LEAF SERVICE-BERRY / 3,12,13,29
"	<i>Amphicarpaea bracteata</i> L. (Fern.) var. <i>bracteata</i> / AMERICAN HOG-PEANUT / 3,12,29,31
"	* <i>Arabis hirsuta</i> (L.) Scop. var. <i>pycnocarpa</i> (M. Hopkins) Rollins / HAIRY ROCKCRESS / 19,23,25,26
"	<i>Aralia nudicaulis</i> L. / WILD SARSAPARILLA / 2,3,12,31
"	* <i>Asclepias exaltata</i> L. / POKE MILKWEED / 5,12,20,29
"	* <i>Cirsium discolor</i> (Muhl. ex Willd.) Spreng. / FIELD THISTLE / 2,12,29,31
"	* <i>Desmodium glutinosum</i> (Muhl. ex Willd.) Wood / POINTED-LEAF TICK-TREFOIL / 3,12,29,31
"	<i>Equisetum hyemale</i> L. var. <i>affine</i> (Engelm.) A.A. Eat. / TALL SCOURING RUSH / 8,10,19,23
"	<i>Erigeron strigosus</i> Muhl. ex Willd. / PRAIRIE FLEABANE / 12,22,23,31
"	* <i>Liatris cylindracea</i> Michx. / ONTARIO GAYFEATHER / 11,25,26,27
"	<i>Lonicera dioica</i> L. / LIMBER HONEYSUCKLE / 2,3,12,29
"	* <i>Lupinus perennis</i> L. ssp. <i>perennis</i> var. <i>perennis</i> / SUNDIAL LUPINE / 3,4,5,7
"	<i>Melampyrum lineare</i> Desr. var. <i>lineare</i> / AMERICAN COW-WHEAT / 2,12,31,32
"	<i>Muhlenbergia mexicana</i> (L.) Trin. / MEXICAN MUHLY / 2,3,12,31
"	<i>Prunus nigra</i> Ait. / CANADIAN PLUM / 3,7,19,29
"	* <i>Saxifraga virginiana</i> Michx. / EARLY SAXIFRAGE / 3,8,12,29
"	* <i>Sedaginella rupestris</i> (L.) Spring / LEDGE SPIKE-MOSS / 8,10,23,32
"	* <i>Taenidia integerrima</i> (L.) Drude / YELLOW-PIMPERNEL / 3,12,23,29
"	<i>Thuja occidentalis</i> L. / EASTERN ARBORVITAE / 5,12,13,22
"	<i>Trillium grandiflorum</i> (Michx.) Salisb. / WHITE TRILLIUM / 2,3,12,29
"	<i>Viburnum acerifolium</i> L. / MAPLE-LEAF ARROW-WOOD / 2,3,12,29

APPENDIX. (continued)

Sites	Scientific/Common Name
4	<i>Viburnum rafinesquianum</i> J.A. Schultes / DOWNY ARROW-WOOD / 3,8,12,13
3	<i>Agrostis scabra</i> Willd. / ROUGH BENT / 2,12,33
"	* <i>Ceanothus herbaceus</i> Raf. / PRAIRIE REDROOT / 5,23,31
"	<i>Celastrus scandens</i> L. / AMERICAN BITTERSWEET / 12,29,31
"	<i>Geranium maculatum</i> L. / SPOTTED CRANE'S-BILL / 5,12,19
"	* <i>Lathyrus ochroleucus</i> Hook. / CREAM VETCHLING / 3,12,20
"	<i>Lonicera hirsuta</i> Eat. / HAIRY HONEYSUCKLE / 2,12,29
"	* <i>Oryzopsis asperifolia</i> Michx. / WHITE-GRAIN MOUNTAIN-RICE GRASS / 2,12,33
"	* <i>Panicum virgatum</i> L. var. <i>virgatum</i> / WAND PANIC GRASS / 8,19,32
"	<i>Parthenocissus quinquefolia</i> (L.) Planch. (incl. <i>P. inserta</i>) / VIRGINIA-CREEPER / 2,12,29
"	<i>Podophyllum peltatum</i> L. / MAY-APPLE / 12,29,31
"	<i>Populus balsamifera</i> L. subsp. <i>balsamifera</i> / BALSAM POPLAR / 2,10,29
"	<i>Populus deltoides</i> Bartr. ex Marsh ssp. <i>deltoides</i> / EASTERN COTTONWOOD / 8,12,27
"	<i>Rubus flagellaris</i> Willd. / WHIPLASH DEWBERRY / 8,12,33
"	* <i>Solidago arguta</i> Ait. var. <i>arguta</i> / ATLANTIC GOLDENROD / 3,12,23
"	<i>Solidago rugosa</i> P. Mill. ssp. <i>rugosa</i> var. <i>rugosa</i> / WRINKLE-LEAF GOLDENROD / 3,12,29
"	<i>Symphyotrichum puniceus</i> (L.) A. & D. Löve / PURPLE-STEM AMERICAN-ASTER / 2,12,31
2	<i>Acer rubrum</i> L. var. <i>rubrum</i> / RED MAPLE / 12,31
"	<i>Actaea pachypoda</i> Ell. / WHITE BANEERRY / 3,12
"	* <i>Andropogon virginicus</i> L. var. <i>virginicus</i> / BROOM-SEDGE / 29,32
"	* <i>Anemone quinquefolia</i> L. var. <i>quinquefolia</i> / NIGHTCAPS / 3,12
"	* <i>Arabis holboellii</i> Hornem. var. <i>retrofracta</i> (Graham) Rydb. / HOLBOELL'S ROCKCRESS / 19,23
"	* <i>Botrychium multifidum</i> (Gmel.) Trev. / LEATHERY GRAPE FERN / 2,33
"	* <i>Carex backii</i> Boott / BACK'S SEDGE / 12,25
"	<i>Cornus canadensis</i> L. / CANADIAN BUNCHBERRY / 2,12
"	<i>Cypripedium parviflorum</i> Salisb. var. <i>pubescens</i> (Willd.) Knight / LESSER YELLOW LADY'S SLIPPER / 3,12
"	<i>Deschampsia flexuosa</i> (L.) Trin. var. <i>flexuosa</i> / WAVY HAIR GRASS / 8,32
"	* <i>Desmodium paniculatum</i> (L.) DC. var. <i>paniculatum</i> / PANICLED-LEAF TICK-TREFOIL / 29,31
"	<i>Eupatorium maculatum</i> L. var. <i>maculatum</i> / SPOTTED JOE-PYE-WEED / 12,31
"	* <i>Grindelia squarrosa</i> (Pursh) Dunal var. <i>squarrosa</i> / CURLY-CUP GUMWEED / 8,19
"	<i>Gnaphalium obtusifolium</i> L. / MARSH CUDWEED / 10,33
"	* <i>Hamamelis virginiana</i> L. / AMERICAN WITCH-HAZEL / 3,29
"	* <i>Luzula acuminata</i> Raf. var. <i>acuminata</i> / HAIRY WOOD-RUSH / 3,12
"	<i>Monotropa hypopithys</i> L. / MANY-FLOWER INDIAN-PIPE / 12,29
"	<i>Pedicularis canadensis</i> L. ssp. <i>canadensis</i> / CANADIAN LOUSEWORT / 12,29
"	<i>Polygala paucifolia</i> Willd. / GAYWINGS / 2,12
"	* <i>Polygonum douglasii</i> Greene ssp. <i>douglasii</i> / DOUGLAS' KNOTWEED / 8,19
"	<i>Pyrrola elliptica</i> Nutt. / SHINLEAF / 3,12
"	* <i>Ranunculus hispidus</i> Michx. var. <i>hispidus</i> / BRISTLY BUTTERCUP / 12,31
"	<i>Rubus odoratus</i> L. var. <i>odoratus</i> / PURPLE-FLOWERING RASPBERRY / 12,19
"	<i>Sanicula marilandica</i> L. / MARYLAND BLACK-SNAKEROOT / 12,29
"	<i>Stellaria longipes</i> Goldie / LONG-STALK STARWORT / 12,29
"	<i>Symphyotrichum lateriflorum</i> (L.) A. & D. Löve var. <i>lateriflorum</i> / FAREWELL-SUMMER / 2,12
"	<i>Tilia americana</i> L. var. <i>americana</i> / AMERICAN BASSWOOD / 3,12
"	<i>Verbena hastata</i> L. var. <i>hastata</i> / SIMPLER'S-JOY / 2,12
"	<i>Viburnum lentago</i> L. / NANNY-BERRY / 2,12
"	<i>Viola canadensis</i> L. var. <i>canadensis</i> / CANADIAN WHITE VIOLET / 29,31
"	<i>Viola pubescens</i> Ait. var. <i>pubescens</i> / DOWNY YELLOW VIOLET / 12,29
1	<i>Acer spicatum</i> Lam. / MOUNTAIN MAPLE / 12
"	<i>Actaea rubra</i> (Ait.) Willd. subsp. <i>rubra</i> / RED BANEERRY / 12
"	<i>Anemone virginiana</i> L. var. <i>virginiana</i> / TALL THIMBLEWEED / 12
"	* <i>Arabis glabra</i> (L.) Bernh. / TOWER MUSTARD / 23
"	<i>Arenaria serpyllifolia</i> L. / THYME-LEAF SANDWORT / 19
"	<i>Betula papyrifera</i> Marsh var. <i>papyrifera</i> / PAPER BIRCH / 12
"	* <i>Carex tonsa</i> (Fern.) Bickn. var. <i>tonsa</i> / SHAVED SEDGE / 23
"	* <i>Cerastium arvense</i> L. ssp. <i>arvense</i> / FIELD MOUSE-EAR CHICKWEED / 29
"	<i>Cerastium fontanum</i> Baumg. ssp. <i>vulgare</i> (Hartman) Greuter & Burdet / COMMON MOUSE-EAR CHICKWEED / 12
"	<i>Circaea lutetiana</i> L. ssp. <i>lutetiana</i> / BROAD-LEAF ENCHANTER'S-NIGHTSHADE / 12
"	<i>Cornus alternifolia</i> L. f. / ALTERNATE-LEAF DOGWOOD / 12
"	<i>Cornus foemina</i> P. Mill. / STIFF DOGWOOD / 12
"	<i>Cornus sericea</i> L. (including <i>C. stolonifera</i>) / REDOSIER / 12
"	<i>Crataegus macrantha</i> / HAWTHORN / 12

APPENDIX. (continued)

Sites	Scientific/Common Name
1	* <i>Desmodium nudiflorum</i> (L.) DC. / NAKED-FLOWER TICK-TREFOIL / 31
"	<i>Doellingeria umbellata</i> (P. Mill.) Nees var. <i>umbellata</i> / PARASOL WHITE-TOP / 2
"	<i>Elymus canadensis</i> L. / NODDING WILD RYE / 19
"	<i>Epigaea repens</i> L. / TRAILING-ARBUTUS / 29
"	<i>Equisetum Xmackaii</i> (Newman) Brichan / (<i>hyemale</i> × <i>variegatum</i>) / 33
"	<i>Gaultheria procumbens</i> L. / EASTERN TEABERRY / 2
"	<i>Gentiana andrewsii</i> Griseb. var. <i>andrewsii</i> / CLOSED BOTTLE GENTIAN / 12
"	<i>Geum aleppicum</i> Jacq. / YELLOW AVENS / 12
"	<i>Geum canadense</i> Jacq. var. <i>canadense</i> / WHITE AVENS / 12
"	* <i>Geum triflorum</i> Pursh var. <i>triflorum</i> / OLD-MAN'S-WHISKERS / 29
"	* <i>Hierchloe odorata</i> (L.) Beauv. / VANILLA GRASS / 12
"	<i>Hieracium canadense</i> Michx. var. <i>divaricatum</i> Lepage / CANADIAN HAWKWEED / 25
"	<i>Lactuca canadensis</i> L. / FLORIDA BLUE LETTUCE / 12
"	<i>Lonicera canadensis</i> Bartr ex Marsh / AMERICAN FLY-HONEYSUCKLE / 12
"	<i>Lycopodium Xhabereri</i> House / (<i>digitatum</i> × <i>tristachyum</i>) / 33
"	<i>Lycopodium tristachyum</i> Pursh / DEEP-ROOT GROUND-PINE / 33
"	* <i>Lysimachia quadriflora</i> Sims / FOUR-FLOWER YELLOW-LOOSESTRIFE / 4
"	<i>Malaxis unifolia</i> Michx. / GREEN ADDER'S-MOUTH ORCHID / 2
"	<i>Monotropa uniflora</i> L. / ONE-FLOWER INDIAN-PIPE / 25
"	<i>Oenothera biennis</i> L. / KING'S CUREALL / 33
"	<i>Oenothera perennis</i> L. / SMALL EVENING-PROMROSE / 27
"	<i>Orobanche uniflora</i> L. / NAKED BROOM-RAPE / 12
"	<i>Orthilia secunda</i> (L.) House / SIDEBELLS / 12
"	<i>Packera paupercula</i> (Michx.) A. & D. Löve / BALSAM GROUNDSEL / 29
"	* <i>Panicum philadelphicum</i> Bernh. ex Trin. / PHILADELPHIA PANIC GRASS / 8
"	* <i>Penstemon digitalis</i> Nutt. ex Sims / FOXGLOVE BEARDTONGUE / 19
"	<i>Polygonatum biflorum</i> (Walt.) Ell. / KING SOLOMON'S-SEAL / 25
"	<i>Prenanthes alba</i> L. / WHITE RATTLESNAKE-ROOT / 12
"	<i>Prenanthes altissima</i> L. / TALL RATTLESNAKE-ROOT / 12
"	<i>Prunus pensylvanica</i> L. f. var. <i>pensylvanica</i> / FIRE CHERRY / 20
"	<i>Pyrola americana</i> Sweet / AMERICAN WINTERGREEN / 12
"	* <i>Ranunculus fascicularis</i> Muhl. ex Bigelow / EARLY BUTTERCUP / 29
"	* <i>Rhus glabra</i> L. / SMOOTH SUMAC / 25
"	* <i>Rosa carolina</i> L. var. <i>carolina</i> / CAROLINA ROSE / 12
"	<i>Rubus occidentalis</i> L. / BLACK RASPBERRY / 33
"	<i>Salix petiolaris</i> Sm. / MEADOW WILLOW / 12
"	<i>Sambucus nigra</i> L. subsp. <i>canadensis</i> (L.) R. Bolli / BLACK ELDER / 12
"	* <i>Scrophularia lanceolata</i> Pursh / LANCE-LEAF FIGWORT / 26
"	<i>Solidago hispida</i> var. <i>hispida</i> / HAIRY GOLDENROD / 12
"	* <i>Spiranthes casei</i> Catling & Cruise var. <i>casei</i> / CASE'S LADIES'-TRESSES / 2
"	* <i>Spiranthes lacera</i> (Raf.) Raf. var. <i>lacera</i> / NORTHERN SLENDER LADIES'-TRESSES / 2
"	* <i>Symphyotrichum amethystinum</i> (Nutt.) Nesom / AMETHYST ASTER / 12
"	<i>Trientalis borealis</i> Raf. / MAYSTAR / 12
"	<i>Triodanis perfoliata</i> (L.) Nieuwl. / CLASPING-LEAF VENUS'-LOOKING-GLASS / 25
"	<i>Triosteum perfoliatum</i> L. / FEVERWORT / 3
"	* <i>Viola affinis</i> Le Conte / SAND VIOLET / 3
"	* <i>Vitis aestivalis</i> Michx. / SUMMER GRAPE / 31
"	* <i>Zanthoxylum americanum</i> P. Mill. / PRICKLY ASH / 29
"	* <i>Zigadenus elegans</i> Pursh ssp. <i>glaucus</i> (Nutt.) Hultén / MOUNTAIN DEATHCAMAS / 29

Additional species at sites for which complete lists are not available:

- * *Lycopodium complanatum* L. / TRAILING GROUND-PINE
- * *Dichantherium oligosanthes* (J.A. Schultes) Gould var. *scribnerianum* (Nash) Gould / HELLER'S ROSETTE GRASS
- * *Gaylussacia baccata* (Wangenh.) K. Koch / BLACK HUCKLEBERRY

Eye Colour, Aging, and Decoy Trap Bias in Lesser Scaup, *Aythya affinis*

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Researchers routinely assume that samples of trapped or captured animals are representative of the overall population, though these assumptions are not always evaluated. We used decoy-trapped Lesser Scaup (*Aythya affinis*) to assess the reliability of classifying females as yearlings or adults from a distance, based on documented age-related eye-colour changes, and also to evaluate the presence of sex, condition and age biases in decoy trapping. We compared eye colour of trapped females to photographs of known-age females following a published procedure while females were (1) in traps (by using spotting scopes or binoculars) and (2) in-hand. Assuming in-hand age assessments were correct, we found that adults aged from a distance were frequently misclassified as yearlings, but yearlings were never misclassified as adults. Distance between observer and female, overall observation quality, and cloud cover did not influence age assignment success. A larger proportion of males was captured than observed during a survey of the local breeding population. We also found that decoy-trapped females had lower body mass and were more likely to be yearlings compared to pass- and jump-shot females from the same area. We conclude that female Lesser Scaup cannot be accurately aged from a distance using eye colour and concur with other researchers that possible sex, age and condition biases should be evaluated when using decoy traps.

Key Words: Lesser Scaup, *Aythya affinis*, age bias, aging techniques, body condition bias, decoy trap, sex bias, trap bias, Saskatchewan, Northwest Territories.

In wildlife studies, individual animals are often sampled and their age, sex, and condition are determined. An implicit assumption of many studies is that different cohorts of a population are equally likely to be encountered relative to that of the wild population at a given time and place. However, true random samples are difficult to collect as some individuals may have an increased probability of being captured. By evaluating sampling techniques, possible biases in sampling can be discovered, minimized and compensated for.

Researchers sample wildlife populations in numerous ways to collect information uniquely suited to the research questions being asked. Age-ratio information is useful for understanding population dynamics and making wildlife management decisions, and may be collected by examining trapped individuals or those killed by hunters or disease (e.g., Lack 1968; Johnson et al. 1992). Age structure also provides a basis for assessing age-specific vital rates (Newton 1988) and estimating productivity. However, some sampling methods (trapping, hunting, observation, collection of diseased animals) could produce biased estimates (Bell-

rose et al. 1961; Weatherhead and Greenwood 1981). Trauger (1974) used the unique characteristic of age-related eye-colour change to develop an aging technique for female Lesser Scaup (*Aythya affinis*, hereafter scaup), and used this technique to estimate annual fluctuations in female age composition of scaup breeding populations by estimating the age of female scaup from a distance. However, the reliability of this method has not been assessed.

Decoy traps are a common capture technique for waterfowl and other birds (e.g., Rogers 1964; Anderson et al. 1980; Weatherhead and Greenwood 1981; Grand and Fondell 1994; Guyn and Clark 1999); however, the use of decoys has been shown to bias sampling for some species, with individuals of one sex (Grand and Fondell 1994), age group (Weatherhead and Greenwood 1981), or body condition (Weatherhead and Greenwood 1981) being more susceptible to capture than others. Given that decoy traps work by attracting individuals into enclosures, it is reasonable to assume that some may be more vulnerable than others, possibly due to differences in experience (age), aggression

(e.g., breeding stage), or promiscuity (Weatherhead and Greenwood 1981; Grand and Fondell 1994). Few studies have reported sex biases for decoy traps. Grand and Fondell (1994) found relatively few Northern Pintail (*Anas acuta*) females were captured in decoy traps compared to baited rocket-nets, but found no difference in number of males captured. Rogers (1964) and Anderson et al. (1980) captured more male than female scaup in decoy traps but did not explicitly test for a sex bias.

Other studies have compared trapping methods to assess body condition and age related trap bias. Guyn and Clark (1999) found no difference in age or body size of decoy-trapped versus nest-trapped Northern Pintails. Grand and Fondell (1994) found relatively few older Northern Pintail females captured in decoy traps compared to baited rocket-nets but found no difference in body mass of either sex between capture methods. Decoy-trapped Red-winged Blackbirds (*Agelaius phoeniceus*) were on average younger and had lower body mass when compared with a mist-netted sample leaving roost sites (Weatherhead and Greenwood 1981). These studies assumed that alternative methods (i.e., rocket-netting, and roost-capture) were not age or condition biased.

In this study, we evaluated field techniques specific for the study of scaup. Here, we evaluated the (1) accuracy of Trauger's (1974) distance aging method and (2) potential sex, body condition and age biases for decoy trapping. We determined the efficacy of using eye colour as a method for aging female scaup from a distance by comparing estimated age classes of birds while in-hand with those estimated for the same birds at various distances using spotting scopes or binoculars. We evaluated sex bias by comparing the ratio of males to females captured in decoy traps versus the ratio observed in the local population during pair surveys. Age- and body-mass-related trap biases were also evaluated by comparing mass and age of decoy-trapped females with shot females.

Methods

Accuracy of distance aging

We captured known-age female scaup on nests from 1998 to 2000, using nest traps (Weller 1957) or mist nets on St. Denis National Wildlife Area (SDNWA; 52°13'N, 106°04'W), located 40 km east of Saskatoon, Saskatchewan, Canada. The SDNWA was described in detail by Sugden and Beyersbergen (1985) and Woo et al. (1993). Nesting female scaup were aged in-hand by two or more observers using the eye colour chart provided in Trauger (1974). Trauger's (1974) eye colour chart provides examples of the progressive change in eye colour from brown to yellow as female scaup age from yearlings to adult birds (3+ years). Age was assigned by consensus (agreement of eye colour chart number) but, if not possible, we recorded individual eye-colour numbers from Trauger's (1974) chart (each

age class is represented by two or more chart eye-colours). If observers disagreed on the age class or the consensus age class did not correspond to the actual age of the female, the in-hand assignment for that female was scored as being incorrect. The accuracy of in-hand aging was determined by comparing a female scaup's known age to that estimated during recapture.

Work was also conducted on the Yellowknife Study Area (YKSA), located 16 km northwest of Yellowknife (62°28'N, 114°24'W), Northwest Territories, Canada. The YKSA was described in detail by Trauger (1971) and Fournier and Hines (1999). We trapped pre-laying scaup between 18 May and 2 June 2000, 24 May and 7 June 2001, 31 May and 16 June 2003, and 2 June and 13 June 2004. Decoy traps were modified from Rogers (1964) and Anderson et al. (1980), and live captive-bred female scaup were used to decoy wild birds. Traps were placed on ponds with frequent scaup use.

We classified female scaup into two age classes, yearlings (1 year old) or older (2+ years), by comparing their eye colour to the eye colour chart examples of known-aged female scaup provided in Trauger (1974). Trauger (1974) reported that 66% of known-age two-year-old females had eye colour that was indistinguishable from three- and four-year-olds. By contrast, he found little overlap in eye colour between yearlings versus three- and four-year-old birds. Accordingly, we classified females as yearlings if their eye colour was brown to olive brown; females with eye colour ranging from olive yellow to yellow were classified as two-year-old or older.

We estimated scaup eye colour for females captured in decoy traps using either spotting scopes (20–60×) or binoculars (8–10×). Two observers estimated each female's age and distance from observer to the trap (to nearest 10 m). Each observer also estimated the percent cloud cover (to assess light quality, 0% to 100%) and their individual observation quality (1 = excellent to 4 = poor, based on observation obstructions, light quality, wind and distance to trap). We then aged the same females in-hand. Observers recorded age assignment in confidence and did not age the female for both age assignments (i.e., each female was aged by at least three researchers) such that observers alternated between age assignment methods (i.e., from a distance versus in-hand) to reduce observer bias in 2000; however, only two observers were present in 2001. In 2003 and 2004, females were only aged in-hand by two observers after being removed from the trap. Age was assigned by consensus; if none could be reached then individual eye colour chart numbers (Trauger 1974) were recorded.

Decoy trap sex bias

Sex was recorded for all decoy trapped scaup captured on the YKSA from 2000 to 2004. Pair survey data were also collected on all ponds on the YKSA and completed during systematic surveys over 2–3 days (Trauger 1971; J. E. Hines, Canadian Wildlife Service,

unpublished data). These surveys occurred in early June each year, during the last few days of the trapping period.

Decoy trap condition and age bias

In 2003 and 2004, we collected female scaup by pass- and jump-shooting (see Greenwood et al. 1986) on wetlands within 75 km northeast of Yellowknife, east of the YKSA where scaup were trapped. We collected female scaup from 24 May to 17 June 2003 and 26 May to 20 June 2004 (overlapping with the decoy-trapping period). Most were collected immediately before and after the decoy-trapping period. All birds were weighed (nearest 5 g) immediately after retrieval and ingesta were removed and weighed (nearest 1 g) later during dissections. We calculated ingesta-free body masses (IFmass) of shot birds by removing actual ingesta mass. All decoy-trapped females from the YKSA were weighed (nearest 5 g) after capture; no mass adjustment was made for these birds because they would have little remaining ingested food after being held in traps for periods of 1–3 hours, then retrieved and handled (Dufour 1991).

Shot females were assigned an age class using eye colour (Trauger 1974; also see above) and wing plumage criteria (Carney 1992); in 2003 and 2004, 24 and 25 females were assigned an age class, respectively. The wing plumage aging criteria for female scaup is based on appearance of tertials, greater tertial coverts, and middle and lesser coverts, allowing fall- and winter-shot females to be aged as immature or adult (Carney 1992). Juvenile scaup females moult a few innermost wing coverts in their first spring (before one-year-old), and therefore retain most of their juvenile wing plumage characteristics (Basic I Plumage) until they moult from Basic I to Definitive Alternate Plumage during their second fall (Palmer 1976; Austin et al. 1998). Therefore, in spring, a female less than a year old would be correctly aged as a one-year-old based on wing plumage and eye colour. When disagreement between aging techniques occurred or when aged using wing plumage only (five in 2003, five in 2004), females were classified into a general category, after hatch year (AHY), for this analysis.

Statistical Methods

Accuracy of distance aging – Field methods and observers differed between 2000 and 2001 when collecting distance-eye-colour data, so years were analyzed separately. The accuracy of distance-aging was determined by comparing age assignments from distant observations versus in-hand age determination, using a Fisher's exact test (PROC FREQ; SAS Institute 2000). We assumed in-hand designation was correct when both observers agreed on female age. We modeled effects of overall observation quality ([observer one individual observer quality + observer two individual observer quality]/2), percent cloud cover, distance from observer to trap, and the interaction between

observation quality and distance from observer to trap on the success of age assignment using general linear models (PROC GLM; SAS Institute 2000). Simpler models were considered and the most plausible model was selected using Akaike's Information Criterion corrected for sample size (AIC_c) and model weight (w_i ; Burnham and Anderson 1998).

Sex bias – We evaluated the possibility of sex bias using a chi-squared test (PROC FREQ; SAS Institute 2000) to compare the sex ratio of trapped scaup (not including recaptures) with that estimated for the YKSA population during annual breeding pair surveys conducted in June (J. E. Hines, CWS, unpublished data).

Body condition and age bias – Body mass and age (yearling, adult and AHY) in the decoy-trapped sample were compared to collected females. We initially plotted data to identify outliers or nonlinear patterns, but none were detected. Least squares means (LSmean) and standard errors (SE) were computed to describe year and method-specific variation in body masses of females. We modeled effects of year (2003, 2004), collection method (decoy trap, shot), day and all two-way interactions on IFmass using general linear models (PROC GLM; SAS Institute 2000). Reduced models were also considered and the most plausible models were selected using AIC_c and model weights (w_i ; Burnham and Anderson 1998). Contingency tables were evaluated using a G-test (PROC FREQ; SAS Institute 2000).

Results

Accuracy of distance aging

Twelve known-age female scaup were captured and aged at SDNWA in spring from 1998 to 2000. When observers agreed, most females were aged correctly as either yearlings or adults (%, 89%). Observers disagreed three times on age assignment (3/2, 25%), all of which occurred when classifying known-age yearlings ($n = 1$) and 2 year-olds ($n = 2$).

A total of 43 decoy-trapped females was aged both from a distance and in-hand on the YKSA during May and June 2000, 2001. There was agreement between observers for 89% and 82% of females aged in-hand in 2000 and 2001, respectively. When both observers agreed on age, for both in-hand and distance aging (60% in 2000 and 41% in 2001), age assignments were correct for 100% of yearlings ($n = 5$) and 56.3% of adults ($n = 16$) in 2000, and 100% of yearlings ($n = 2$) and 80.0 % of adults ($n = 5$) in 2001. Assuming in-hand age assignments are correct when both observers agree, in 2000, aging from a distance underestimated the age of female scaup (Fisher's exact, 2-sided, $P = 0.04$, $n = 21$, Figure 1); many adults were mis-assigned as yearlings. However, in 2001, only one female's age was underestimated from a distance ($n = 7$).

There was no significant difference between years in observers' ability to age females correctly ($\chi^2_1 = 0.87$, $P = 0.35$). Our ability to age females correctly from a

distance was best modeled when we included distance as a covariate ($AIC_c = -38.42$, $w = 0.20$); however, considerable variation remained ($r^2 = 0.003$). This model was only slightly better than the models which included the effect of cloud ($\Delta AIC_c = 0.09$, $w = 0.19$), overall observation quality ($\Delta AIC_c = 0.20$, $w = 0.18$), and cloud with overall observation quality ($\Delta AIC_c = 0.90$, $w = 0.13$).

Decoy trap sex bias

We caught 52 ($n = 35$ in 2000; $n = 17$ in 2001) female and 164 ($n = 81$ in 2000; $n = 83$ in 2001) male scaup in decoy traps during May and June on the YKSA. Relatively more males were captured in traps than were observed during a survey of the study area (2000: $\chi^2_1 = 8.2$, $P < 0.005$; 35 females and 81 males decoy-trapped; 254 females and 317 males observed on June survey; 2001: $\chi^2_1 = 21.9$, $P < 0.005$; 17 females and 83 males decoy-trapped; 191 females and 271 males observed on June survey) (Figure 2).

Decoy trap condition and age bias

We shot 29 and 30 and decoy-trapped 17 and 25 females in 2003 and 2004, respectively. Overall, females were heavier in 2003 than in 2004 (LSmean \pm SE: 727 ± 8 g versus 676 ± 7 g), and shot birds averaged ~ 31 g heavier than decoy-trapped females (717 ± 7 g versus 686 ± 8 g). Variation in female body mass was best modeled by including effects of year, collection method, day and the interaction between day and year in the model ($AIC_c = 375.08$, $w = 0.351$, $R^2 = 0.369$). This model was slightly better than the two next best which either lacked the interaction term between day and year ($\Delta AIC_c = 1.18$, $w = 0.194$), or lacked collection method ($\Delta AIC_c = 1.23$, $w = 0.190$). Two additional plausible models ($\Delta AIC_c < 2.70$) included effects of collection method, year, day and interactions involving year*day and year*method ($w = 0.112$), or simply included year and day effects ($w = 0.095$). Because the year*day and, to a lesser extent, year*method interactions were influential, we analyzed each year separately. Body mass did not vary with age; after accounting for year, method, day and day*year interaction effects, 63 adult females (mean \pm SE, 706 ± 7 g) averaged 13 g heavier than 24 yearling females (693 ± 11 g), whereas 14 AHY females had intermediate masses (701 ± 15 g). In a separate analysis of 2003 females, variation in body mass was only weakly related to age (LSmean \pm SE, adjusted for collection date: adult = 728 ± 14 g, yearling = 718 ± 14 g) or collection method (trap = 713 ± 16 g; shot = 733 ± 14 g). There was considerable annual variation in the proportion of yearlings captured in decoy traps, ranging from 16–82%, with an overall average of 37% during 2000–2004. Of birds collected by shooting, 17% of 24 and 92% of 25 were yearlings, versus 82% of 17 and 81% of 21 females captured in decoy traps, in 2003 ($G_1 = 18.8$, $P < 0.001$) and 2004 ($G_1 = 1.23$, $P = 0.27$), respectively.

Discussion

Accuracy of distance aging

The distance-aging technique for female scaup did not provide a reliable estimate of population age ratio (yearling:adult) when compared to in-hand aging and would result in an overestimation of yearlings (assuming in-hand age was correctly assigned). Distance aging was not strongly affected by estimates of observation quality (e.g., estimated distance to the trap, percent cloud cover, and overall observation quality) though our sample size may not have been adequate to fully assess these potential covariates. The technique's inaccuracy may be due to observers' inability to distinguish subtle colour differences between yearlings and two-year-olds. Trauger (1974) described the colour for yearlings as dark brown, olive brown and light olive brown versus light olive brown and olive yellow for two-year-olds (i.e., overlapping). This overlap in colour could explain the disagreement that occurred between observers handling both known-age and trapped females. Additionally, Trauger (1974) also suggested that within-season eye-colour changes may occur, especially in these age classes; and could also explain our discrepancies. If we had chosen to classify female scaup aged from a distance into \leq two-year-olds and three-year-old categories, we might have increased our age classification success. However, the age categories that we chose represented both a change in eye colour and a biologically important change in female reproductive performance; yearling female diving ducks (including *Aythya* spp.) typically are less likely to nest in poor habitat, have smaller clutches, lower nest success, and lower re-nesting rates than older females (Afton 1984; Serie et al. 1992; Blums et al. 1997; Hohman and Eberhardt 1998; Woodin and Michot 2002).

Sex bias

We found a male capture bias for decoy traps compared to the local population of males observed during surveys. Similarly, Grand and Fondell (1994) and Guyn and Clark (1999) decoy trapped 4 to 10 times more male Northern Pintails than females. Anderson et al. (1980) also captured more male than female scaup using decoy traps but captured more female Canvasbacks (*Aythya valisineria*) and Redheads (*Aythya americana*) than males. They suggested this was due to a greater proportion of unpaired male scaup than Canvasbacks or Redheads in the area and because of species behaviour differences. June breeding survey data for the YKSA indicated the majority of males were paired (paired = 192, unpaired = 64 in 2000; paired = 190, unpaired = 81 in 2001, J. E. Hines, CWS, unpublished data). As these surveys occurred during the end of the trapping period, the estimate for unpaired males may be biased low for the entire trapping period. However, we suggest that behaviour of scaup (i.e., largely nonaggressive, social, common mate changes during early breeding season; Austin et

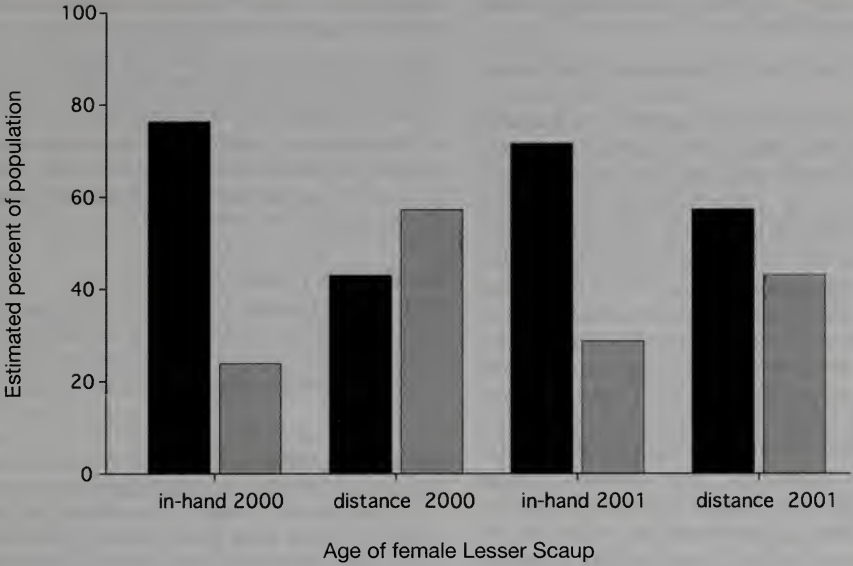


FIGURE 1: Age distribution of adult and yearling female Lesser Scaup trapped on the Yellowknife Study Area, May and June 2000 ($n = 21$) and 2001 ($n = 7$), as determined by in-hand and distant eye-colour aging technique. Black bars indicate adults and grey bars indicate yearlings.

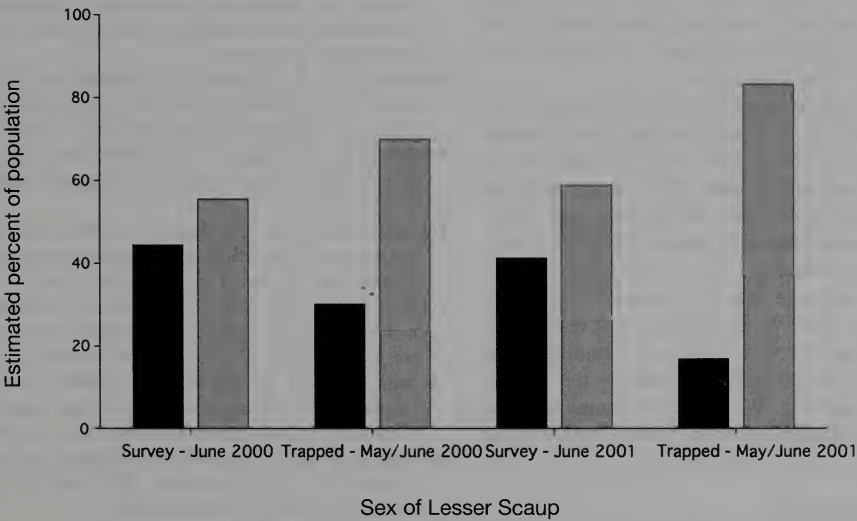


FIGURE 2. Lesser Scaup sex proportions estimated from a June breeding survey and decoy-trapping on the Yellowknife Study Area, May and June 2000 and 2001. Black bars indicate females and grey bars indicate males.

al. 1998) may also be important in explaining sex trap bias than male pair status.

Body condition and age bias associated with decoy traps

Pass- and jump-shooting are methods often used to collect waterfowl specimens to avoid bias associated with other methods including decoying, baiting or calling (Greenwood et al. 1986; Heitmeyer et al. 1993; Anteau and Afton 2004; this study). Although it is possible that certain individuals may be more susceptible to pass and jump-shooting (e.g., if larger or smaller-bodied birds are more likely to survive crippling injury and escape recovery; if birds of a certain size class are more likely to fly along wetland edges where hunting risks may be greater), most shot birds were recovered (>80%) and we believe the method likely provides a more representative sample of local populations than other sampling techniques. Decoy-trapped females were lighter than shot females after accounting for temporal effects and ingesta mass. The difference was more pronounced in 2004, when females generally were lighter than in 2003, possibly due to a late spring thaw (Environment Canada 2004*) which may have reduced food availability (Devink et al. 2008). We suspect the mass difference between methods was due to a greater proportion of yearlings or poorer quality females in the decoy-trapped sample, but could not test this hypothesis. Ryan (1972) and Anderson and Warner (1969) found yearling scaup were lighter and smaller (respectively), but we were unable to detect differences in female weight between age classes. These potential age and body condition biases should be an important consideration for research assuming an unbiased sample of the population.

The trap and age estimation biases we report likely transcend species (e.g., scaup, Rogers 1964; Canvasback, Redhead, and scaup, Anderson et al. 1980; Northern Pintail, Grand and Fondell 1994; Guyn and Clark 1999; Red-winged Blackbirds, Weatherhead and Greenwood 1981; Brown-headed Cowbirds (*Molothrus ater*), Dufour and Weatherhead 1991) where aging is much more difficult and age-specific capture bias is more difficult to determine. We recommend that researchers using decoy traps recognize that age, condition, and sex bias likely occur, and acknowledge this during analysis and reporting. We do not recommend using the eye-colour change technique to age female scaup from a distance.

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APPENDIX 1. Table of models considered in statistical analysis (and compared on basis of AIGc values) for (a) determining if observation variables (overall observation quality, distance from observer to trap, percent cloud cover) had an influence on an observers' ability to correctly distance age female scaup and (b) determine if collection variables (collection method, day, year) had an influence on ingesta-free mass of female scaup.

a) MODEL	<i>n</i>	<i>K</i>
dist	28	3
cloud	28	3
avqual	28	3
cloud, avqual	28	4
avqual, dist	28	4
avqual, dist, cloud	28	5
cloud, dist	28	4
cloud, avqual dist*avqual	28	5
avqual, dist, cloud, dist*avqual	28	6
b) MODEL	<i>n</i>	<i>K</i>
method year day	102	5
method year	102	4
method day	102	4
year day	102	4
method	102	3
day	102	3
year	102	3
method year day method*year	102	6
method year method*year	102	5
year day year*day	102	5
method year day day*method	102	6
method day day*method	102	5
method year day method*year year*day	102	7

Nesting Biology of Lesser Canada Geese, *Branta canadensis parvipes*, along the Tanana River, Alaska

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Lesser Canada Geese (*Branta canadensis parvipes*) are widespread throughout interior regions of Alaska and Canada, yet there have been no published studies documenting basic aspects of their nesting biology. We conducted a study to determine reproductive parameters of Lesser Canada Geese nesting along the Tanana River near the city of Fairbanks, in interior Alaska. Fieldwork was conducted in May of 2003, and consisted of locating nests along the riparian corridor between Fairbanks and Northpole, Alaska. Nests were found on gravel islands and shore habitats along the Tanana River, and were most commonly observed among driftwood logs associated with patches of alder (*Alnus* spp.) and willow (*Salix* spp.). Peak of nest initiation was 3-8 May, with a range from 27 April to 20 May; renesting was likely. Clutches ranged in size from 2 to 7 eggs and averaged 4.6 eggs. There was a negative correlation between clutch size and date of nest initiation. Egg size (\bar{x} mass = 128 g) was similar to other medium-sized Canada Geese. A positive correlation between egg size and clutch size was likely related to female age. Nineteen of 28 nests (68%) were active when visited; nests located on islands with nesting Mew Gulls (*Larus canus*) were more likely to be active than nests located elsewhere. Evidence at nest sites implicated Bald Eagles (*Haliaeetus leucocephalus*) and Red Foxes (*Vulpes vulpes*) as nest predators.

Key Words: Lesser Canada Goose, *Branta canadensis parvipes*, clutch, eggs, nesting ecology, Tanana River, Alaska.

Of the different subspecies of Canada Geese (*Branta canadensis*) that breed in Alaska and across northern Canada, the Lesser Canada Goose (*B. c. parvipes*) occupies the largest geographic area. Although the extent of the nesting distribution of Lesser Canada Geese is not completely known, their core breeding range is presumed to be interior Alaska, through Yukon Territory, northern British Columbia, northern Alberta, and western Northwest Territories [NWT] (Figure 1; Grieb 1970; Bellrose 1976; Johnson et al. 1979; Mowbray et al. 2002; Pearce and Bollinger 2003; Scribner et al. 2003). Lesser Canada Geese overlap with the breeding distribution of Taverner's Cackling Geese (*B. hutchinsii taverneri*) in northern and western Alaska, and with Richardson's Cackling Geese (*B. h. hutchinsii*) across northern and eastern NWT and Nunavut (Dickson 2000; Hines et al. 2000; U. S. Fish and Wildlife Service 2003). Despite this wide breeding distribution, there have been no published investigations of the nesting ecology of Canada Geese in interior regions of northern Canada or Alaska (Bellrose 1976; Mowbray et al. 2002). Until this study, information on the reproductive attributes of *B. c. parvipes* has largely been inferred from studies in northern Canada of coastal-nesting *B. h. hutchinsii* (MacInnes 1962; MacInnes et al. 1974; Carriere et al. 1999). An increased understanding of the breeding biology of Canada Geese nesting in interior areas of Alaska and northwestern Canada will extend our appreciation of the diversity and adaptability of this ubiquitous goose and eventually lead to population management that can account for factors influencing reproductive performance.

Study Area and Methods

The study area was located in the Tanana River floodplain ecosystem, near Fairbanks, Alaska (64°45'N 147°27'W), in the Fairbanks Northstar borough (Figure 1). Annual spring flooding scours the waterway and deposits driftwood on gravel bars and islands, braids stream channels, and maintains an early succession vegetation structure.

We visited the study area once in May 2003. Nests were located by travelling along the river by jet boat. Based on the number of geese and nests observed during initial searches, we focused subsequent search efforts within likely habitat areas using subjective criteria. A nest without feathers or eggs was not deemed active in the current nesting season unless the nest bowl was well developed and contained enough new nest material to cover an egg, as geese commonly make more than one scrape while selecting a suitable nest site but do not add grass to the bowl until an egg is laid (Mowbray et al. 2002). We determined the age of the eggs in the nest either by candling the eggs (Weller 1956) or by floating them to determine air cell volume (Westerskov 1950; Walter and Rusch 1997). When floating eggs, we identified 10 different float stages (four more divisions than Walter and Rusch 1997); estimates of nest age likely were accurate within < 3 days (C. Ely, unpublished data on *B. h. minima*). Nest initiation dates were calculated by back-dating, assuming an incubation period of 26 days and one egg laid every 30 hours (Mowbray et al. 2002).

Egg volume (mL) was determined using the equation $L \times B^2 \times K$, where K is an egg-shape constant

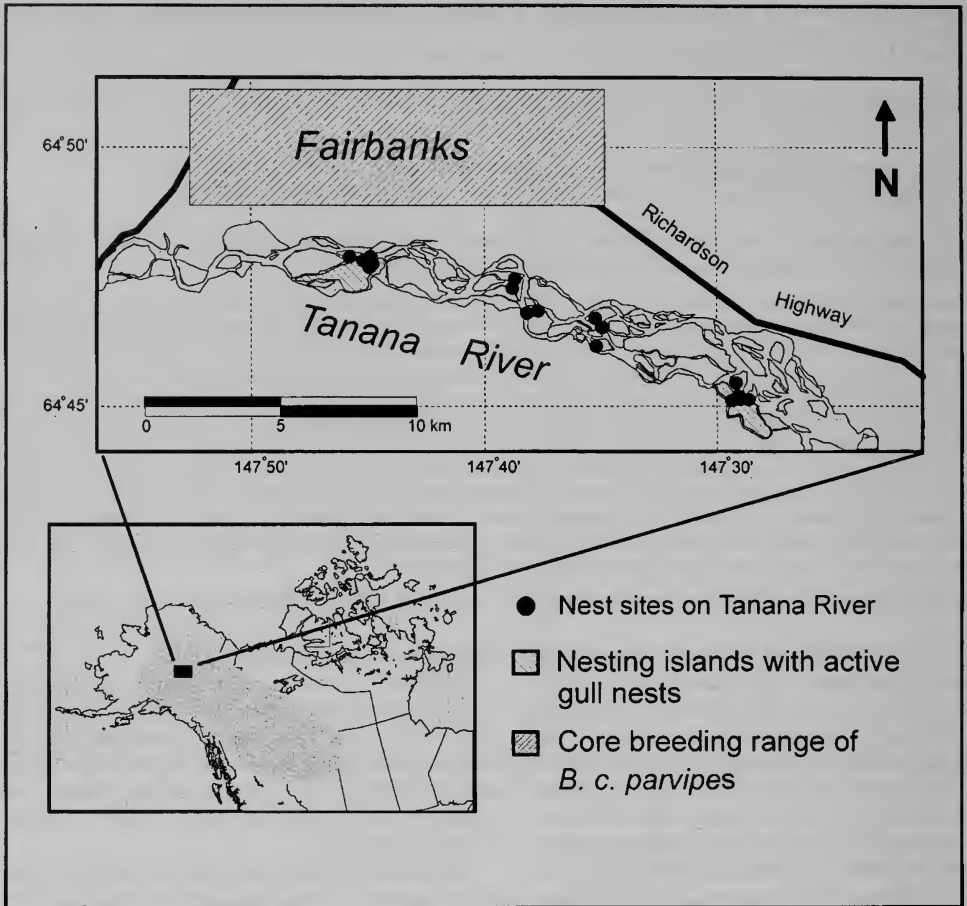


FIGURE 1. Location of Lesser Canada Goose study area on the Tanana River, Alaska, and breeding distribution of *B. canadensis parvipes* (after Grieb 1970; Bellrose 1976; Johnson et al. 1979; Mowbray et al. 2002).

determined to be 0.000556 for Canada Geese (Hoyt 1979; Mowbray et al. 2002). We tested for differences in nesting success between locations using a Fisher's Exact Test modification of a Chi-Square analysis (SAS Institute 1989). The relationship between clutch size and laying date was tested using regression analysis (SAS Institute 1989).

Results and Discussion

Nest Initiation

Timing of initiation of first nests varied from 27 April to 20 May, with a peak of 3-8 May (Figure 2). Timing of nesting in northern geese varies with habitat conditions (Raveling 1978). Habitat conditions during our study were likely similar to an average year. River ice broke on the Tanana River at Nenana, Alaska (about 80 km downstream from the study area) on 29 April in 2003, similar to the long-term average (\bar{x} = 1 May, range 21 April – 15 May; 1990 – 2002;

National Snow and Ice Data Center 2003). Our sample of nest initiation dates hence likely represents an average year. Extended periods of nest initiation are common in Cackling and Canada goose populations that frequently renest, and we suspect that nests initiated after 12 May were renests (see below).

Nest Sites and Habitat

Geese selected sites on large (>100 m) islands within the Tanana flood plain. Island substrates were largely composed of gravel, sand and small boulders, with little organic matter accumulation due to a high frequency of dynamic flooding. Vegetation on islands reflected soil types and was dominated by early succession alder (*Alnus* spp.), willow (*Salix* spp.), cottonwood and poplar (*Populus* spp.). Soils were well-drained and hence few graminoids were present. White Spruce (*Picea glauca*) was abundant on the perimeter of the flood plain. Goose nests were commonly

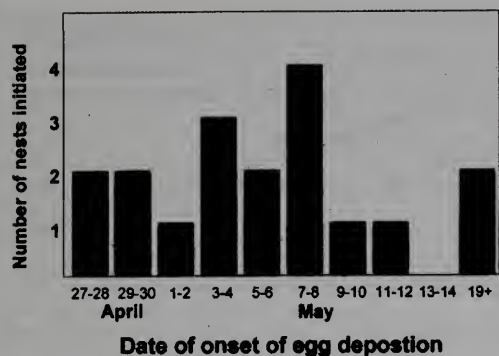


FIGURE 2. Timing of nest initiation of Lesser Canada Geese along the Tanana River, Alaska in 2003.

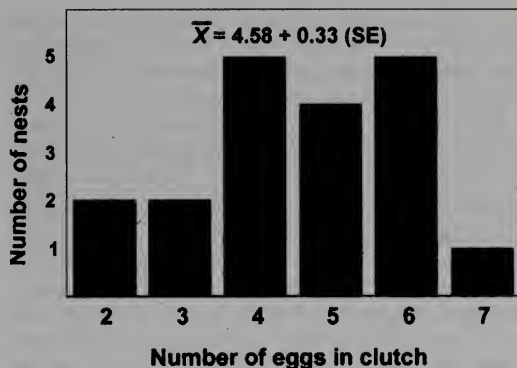


FIGURE 3. Distribution of clutch sizes of Lesser Canada Geese nesting along the Tanana River, Alaska in 2003.

found among driftwood logs that had been deposited during high water on the Tanana River. A few islands of slightly higher elevation were dominated by large cottonwoods; on those islands organic soils supported a thick understory of vegetation, which often included wild rose (*Rosa* spp.) and various grasses and forbs. Nests on those islands were located on the perimeter of the island – presumably to improve predator detection.

Use of riverine habitats by nesting Canada Geese is common throughout their breeding range, and has been particularly noted for *B. c. moffitti* in the Pacific Northwest (Culbertson and Buss 1971; Reese et al. 1987). T. Barry (in Grieb 1970) reported that *B. c. parvipes* nesting in the Mackenzie drainage of Northwest Territories and northern Alberta used mostly streambanks, islands in rivers, and Beaver (*Castor canadensis*) ponds, and stated that they “definitely prefer faster moving water to nest by”. In contrast, *B. h. hutchinsii* and *B. h. taverneri* generally nest on coastal flats or tundra habitat (Grieb 1970; Johnson et al. 1979). However, much needs to be learned about the distribution of the different subspecies of northern-nesting Canada and Cackling geese before any variation in habitat preferences can be fully understood, as the breeding range of *B. c. parvipes* abuts (and overlaps with?) *B. h. taverneri* in the west and *B. h. hutchinsii* in northeastern Alaska, northern Yukon, Northwest Territories, and Nunavut (Mowbray et al. 2002).

Clutch Size

The mean clutch size was 4.58 ± 0.33 (SE) eggs (Figure 3). Clutches were slightly larger than reported for *B. h. hutchinsii* in Canada (4.3 eggs; MacInnes et al. 1974), and similar to clutch sizes of *B. h. taverneri* in Alaska (4.5 – 4.6 eggs on Colville River Alaska, 4.6 eggs on Yukon-Kuskokwim Delta, and 5.9 on the Seward Peninsula; Mowbray et al. 2002). Early nesting birds laid more eggs than birds nesting later, which led to a seasonal decline in clutch size ($F_{1,16} = 6.60$, $P = 0.02$; Figure 4). Such a phenomenon is common

in waterfowl and thought to be related to female age (older females generally nest earlier than inexperienced breeders; Aldrich and Raveling 1983) and the lesser energy reserves later-nesting females have available to devote to egg formation (Alisauskas and Ankney 1992).

Egg Size

Eggs had a mean length of 79.7 ± 0.39 mm (SE) and a width of 53.74 ± 0.17 mm. Mean egg volume of 128.12 mL was similar to eggs of *B. h. taverneri* from the Yukon-Kuskokwim Delta (121 mL; B. McCaffery, personal communication; Mowbray et al. 2002), and the North Slope of Alaska (123 mL; Western Foundation of Vertebrate Zoology, unpublished data), and *B. c. parvipes* from Cook Inlet (125 mL; J. Hupp, unpublished data) and *B. h. hutchinsii* nesting in northern Nunavut (124 mL; MacInnes and Dunn 1988). Egg volume was positively correlated with clutch size ($r = 0.425$, $P < 0.0001$; $n = 80$ eggs in 19 nests), as might be expected given that both egg size and clutch size increase with female age in Canada Geese (Mowbray et al. 2002).

Nest Predation

Nineteen of 28 nests (68%) were active when visited. We visited nests only once, so estimates of nest success are only an index, and only indicative of true nesting success if: (1) active and inactive nests were equally likely to be detected, and (2) all nests active at the time of their discovery survived the remainder of the nesting period. It is unlikely that both these assumptions were met, so our estimates of nesting success are likely inflated. Evidence at destroyed nests implicated Bald Eagles (*Haliaeetus leucocephalus*) and Red Foxes (*Vulpes vulpes*) as nest predators; both are common predators of Canada Goose eggs in Alaska (Anthony et al. 2004). Additional predators that are common in the area and could cause nest loss included Wolves (*Canis lupus*), Coyotes (*Canis latrans*), Grizzly Bears (*Ursus horribilis*) and American Marten

(*Martes americana*), as well as Glaucous Gulls (*Larus hyperboreus*). One island near a landfill supported an abundant Common Raven (*Corvus corvus*) population; it contained one nest that was inactive.

Nests located on islands with nesting Mew Gulls (*Larus canus*) were more likely to be active than nests located elsewhere. Sixteen of 17 (94%) goose nests located on islands with gull colonies were active when discovered, compared to only 3 of 11 (27%) active nests found at locations without nesting colonies of Mew Gulls ($\chi^2 = 13.68$, $df = 1$, $P = 0.0004$). The apparent higher proportion of active nests on islands with gulls seems likely related to an absence of terrestrial predators rather than any nest protection gulls might offer geese nesting in the vicinity. Goose nests were not in close proximity to gull nests, and gulls did not harass observers away from their nests. A similar situation has been reported for island-nesting Red-breasted Geese (*B. ruficollis*) on the Taimyr Peninsula (Quinn et al. 2003).

Many goose nests were located among driftwood logs, and hence were situated at the elevation of the highest floods. Flood stage on the Tanana at Fairbanks is considered to be 7.5 m (National Oceanic and Atmospheric Administration 2003), and has been attained 4 times in the past decade (National Oceanic and Atmospheric Administration 2003). Flooding events usually occur in July and August due to heavy rainfall in the Tanana River Basin. As such, most flooding events occur after incubation has been completed, although occasional floods in late June could impact birds that re-nest or delay nest initiation.

Distribution

Band-return data indicate that Canada Geese from the Tanana River region and elsewhere in interior Alaska winter primarily in eastern Washington, eastern Oregon, and southern British Columbia (Mowbray et al. 2002; C. Ely, unpublished data). This distribution is distinct from Canada Geese nesting in the vicinity of Cook Inlet (400 km south of the Tanana; also assigned to *B. c. parvipes* – see Scribner et al. 2003), that winter mostly in western Oregon and Washington, and tundra-nesting *B. h. hutchinsii* and *B. c. parvipes* populations which breed from northeast Alaska through Yukon Territory, Northwest Territories, and Nunavut (Grieb 1970; Mowbray et al. 2002) that predominantly winter in the Central Flyway. However, affinities of waterfowl based on band return data alone can be difficult to interpret, and genetic studies are currently underway to better understand the distribution and breeding ranges of *B. c. parvipes* and *B. h. taverneri* in Alaska.

Acknowledgments

We thank M. Eicholz for directing us to locations where we would likely find goose nests, and to the early cartographer who appropriately named one of the islands in our study area "Goose Island". J. Hupp

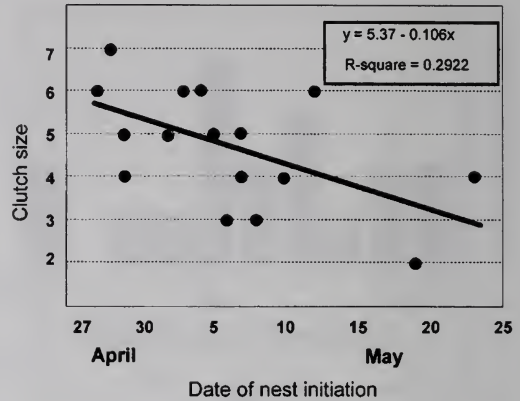


FIGURE 4. Seasonal decline in clutch size of Lesser Canada Geese nesting along the Tanana River, Alaska in 2003.

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Lesser Snow Geese, *Chen caerulescens caerulescens*, and Ross's Geese, *Chen rossii*, of Jenny Lind Island, Nunavut

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We surveyed the Lesser Snow (*Chen caerulescens caerulescens*) and Ross's geese (*Chen rossii*) of Jenny Lind Island, Nunavut, using aerial photography in June 1988, 1998, and 2006, and a visual helicopter transect survey in July 1990. The estimated number of nesting geese was $39\,154 \pm SE\,2238$ in 1988, $19\,253 \pm 2323$ in 1998, and $21\,572 \pm 1898$ in 2006. In 1988 an estimated 2.7% of the nesting geese were Ross's. The July 1990 population of adult-plumaged birds was $25\,020 \pm 3114$. The estimated percentage blue morph among Snow and Ross's geese was 19.0% in 1988, 25.1% in 1989, 23.0% in 1990 and 21.1% in 2006. Estimated pre-fledged Snow Goose productivity was 47% young in 1989 and 46% in 1990. Combined numbers of Snow and Ross's geese on Jenny Lind Island grew over 250 fold, from 210 adults in 1962-1966 to 54 100 adults in 1985. Numbers subsequently declined, to 42 200 in 1988, 25 000 in 1990, 20 300 in 1998, and 26 400 in 2006. Population decline between 1985 and 1990 was consistent with anecdotal reports by others that die-offs of Snow Geese occurred in 1984, 1985 and 1989, and with our August 1989 fieldwork which found evidence of habitat degradation and malnourishment of young geese. In spite of limited food resources on Jenny Lind Island, the colony continued to exist in 2006 at near its 1990 and 1998 levels. Further studies there could provide insights for management of the overabundant mid-continent Snow Goose population and its arctic habitats.

Key Words: Lesser Snow Goose, *Chen caerulescens caerulescens*, Ross's Goose, *Chen rossii*, population, overabundance, nesting, Jenny Lind Island, Nunavut.

Jenny Lind Island (JLI), Nunavut in the Central Canadian Arctic (Figure 1), supports a colony of Lesser Snow Geese (*Chen caerulescens caerulescens*) with a small number of associated Ross's Geese (*Chen rossii*) (Kerbes 1994). Although the Snow Geese of JLI are a tiny part (< 1%) of the Midcontinent Snow Goose Population, they illustrate in microcosm the recent concern about the increasing size of that population and its effects on arctic habitats (Abraham and Jefferies 1997). While the number of adults on JLI grew from an estimated 210 in 1962-1966 (Parmelee et al. 1967) to 54 100 in 1985 (McCormick and Poston 1988) and subsequently declined to less than half that number by 1998, the Midcontinent Population increased from approximately 1 million nesting birds in the early 1970s to 3.8 million in 1998 (Kerbes et al. 2006). Grazing and grubbing by Snow Geese in parts of their arctic range on southern and western Hudson Bay have damaged coastal staging, nesting and moulting habitats, with subsequent decreases in the numbers of nesting birds at colonies in those areas (Kerbes et al. 1990; Abraham and Jefferies 1997; Kerbes et al. 2006). Given the very small amount of nesting, moulting, and brood-rearing habitat on JLI, and the "confinement" of flightless moulting adult geese and their young to the island for most of the summer, it might be expected that the JLI colony would have collapsed very quickly (see Kerbes et al. 1990; Cooch et al. 1991; Francis et al. 1992). In this report we describe goose population sur-

veys done on JLI in 1988, 1989, 1990, 1998, and 2006, and review earlier records. We investigate anecdotal reports of large numbers of geese dying on or near the island in the 1980s and speculate on how this colony has continued to exist, despite the island's apparent shortage of habitat.

Study Area

Jenny Lind Island (68°43'N, 101°58'W) in Queen Maud Gulf of the Arctic Ocean covers about 422 km² and measures about 30 km at its widest point (Figures 1 and 2). It lies 100 km north of the Queen Maud Gulf Migratory Bird Sanctuary (QMG), which supports major nesting colonies of Snow and Ross's geese (Kerbes et al. 2006). Part of the Arctic Lowlands Physiographic Region (Bostock 1970), the island is in the Low Arctic Ecoclimatic Region (Ecoregions Working Group 1989). However, the relatively exposed position of the island and the lack of protective relief led Parmelee et al. (1967) to describe the environmental conditions as High Arctic. The island has gently rolling terrain with a maximum elevation of 61 m above sea level. Most of the island has little or no vegetation. Extensive areas of sand and gravel in the southeast, and of gravel and rocks on the northern and western coasts, are almost devoid of vegetation (McCormick and Poston 1988). Extensive areas of lowland sedge tundra occur only in the central-western portion of the island. In general, the vegetation consists of mesic to

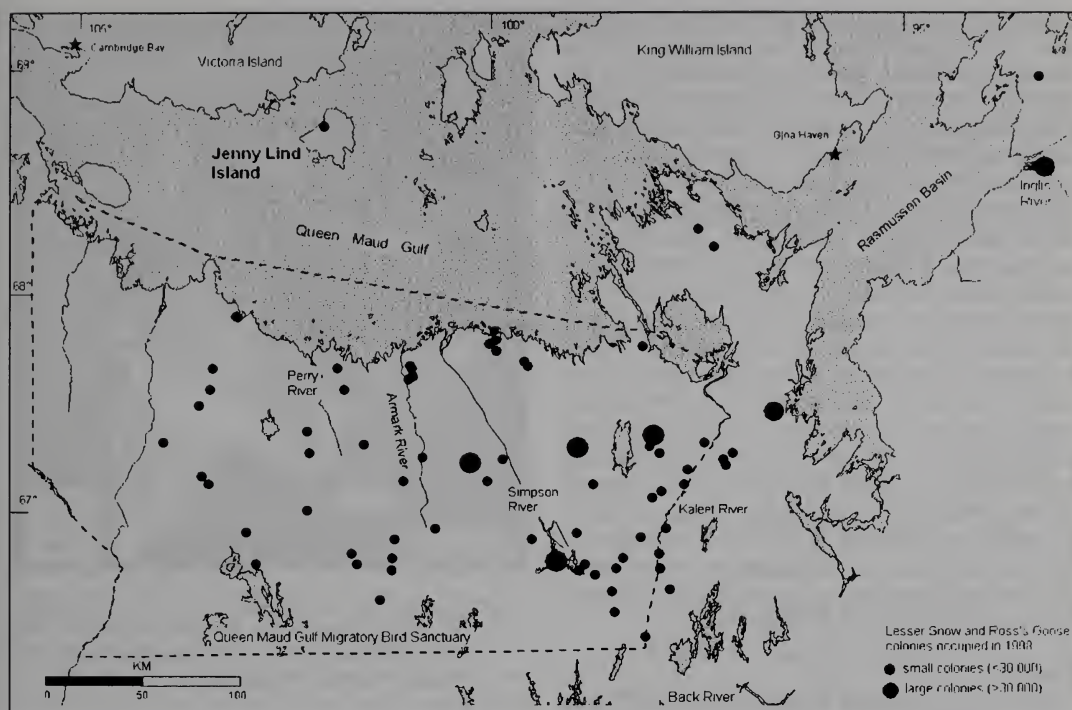


FIGURE 1. Jenny Lind Island, Nunavut, and surrounding area in the central Canadian Arctic, showing Lesser Snow and Ross's goose colonies (dots) active in 1998.

dry/mesic communities dominated by graminoids, forbs and dwarf willows (*Salix* spp.). A Distant Early Warning (DEW) Line station on JLI was occupied from 1952 to 1992.

Methods

Numbers of Snow and Ross's geese nesting on JLI were estimated using large format aerial photography (Kerbes et al. 1983; Kerbes 1994). Prior to obtaining the photos, a reconnaissance of the island was flown to ensure that all nesting areas were covered. Nesting geese were photographed on 18 June 1988 from a DHC Twin Otter aircraft using a Wild RC-10 camera with Panatomic-X and Color Infra Red film; on 22 June 1998 from a Partenavia aircraft using a Zeiss RMK-9 camera with PlusX film; and on 21 June 2006 from a Partenavia using a Zeiss LMK 2000 camera and PlusX film. Each year images of geese from sample areas of the colony were counted visually from the original film negatives, with a Wild M7 binocular microscope. Since they cannot be distinguished separately on the film, the sample counts of white morph Snow Geese and Ross's Geese were combined. They were classified as nesting (on the ground, in pairs or singles) or non-breeding (flying, or on the ground in groups of five or more birds).

Non-breeding geese are here defined as the yearlings and some older birds that have not bred, plus birds which have already failed in their nesting attempt

and have abandoned their nest and its territory. *Adult-plumaged geese* include both the successful nesting birds and the non-breeders. Our estimates of total adult-plumaged birds in 1988, 1998 and 2006 included only those non-breeders which were in, or within approximately 500 m of, the occupied nesting area. Our estimate of total adult-plumaged birds was low by an unknown, but probably small, factor in those years because some non-breeders can also be found further from the colony.

On 21 June 1988 helicopter support allowed ground data on species and colour morph composition to be obtained by three observers at each of three sites within the colony. Samples of nests were classified as Snow or Ross's based on egg size, and samples of nesting geese were classified as white Snow, blue Snow or Ross's based on visual examination with binoculars (Kerbes 1994). Limited budget and logistics prevented similar ground information from being collected in 1998 and 2006. The percentage of blue Snow Geese among combined Snow and Ross's geese was estimated in 1988 using nesting birds from low level photos, and in 2006 using flying birds from high level photos. In August 1989 Snow Geese were banded on JLI using helicopter-supported methods (see Timm and Bromley 1976).

On 28 July 1990, following methods used in 1985 by McCormick and Poston (1988), an aerial survey of goose broods and flightless moulting adult-plumaged

geese was conducted with a Bell 206B helicopter on floats, flying straight transects at an altitude of 45 m above ground and a ground speed of 80 km/hr. An observer in the left front seat recorded all sightings of geese within 200 m of the left side of the aircraft and a second observer in the right rear seat recorded sightings within 200 m on the right side. North-south transects were spaced at distances of 2 km and were divided into 3 km segments which served as the basis for recording data. Estimates and standard errors of goose numbers were calculated by the ratio method (Jolly 1969). Because we sampled a relatively large part of the island, a "finite population correction" was applied to improve the precision of the standard error estimates (Cochran 1977: 24). On 29 July 1990, ground observations were made with a 60-power spotting scope to determine age and colour morph ratios among Snow Geese. Nine adult Snow Geese were collected by shotgun and sent to the Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, for necropsy. General observations on habitat conditions, including evidence of goose grazing pressure, were recorded in 1988, 1989, and 1990.

Results

The estimated number of June-nesting adult Snow and Ross's Geese in the colony declined from $39\,154 \pm SE\,2238$ in 1988 to $19\,253 \pm SE\,2323$ in 1998, but then increased to $21\,572 \pm SE\,1898$ in 2006 (Table 1). We estimated that $25\,020 \pm SE\,3114$ adult-plumaged Snow and Ross's geese and $1045 \pm SE\,233$ Cackling Geese (*Branta hutchinsii*) were present on JLI in July 1990. The ground survey in June 1988 indicated that 2.7% of the nesting Snow and Ross's geese were Ross's, giving an estimate of $1067 \pm SE\,430$ Ross's and $38\,087 \pm SE\,2238$ Snow. Percentage blue morph among Snow and Ross's geese from ground counts and low-level photos was 19.0% in 1988 (of 2595 nesting adults) and 23.0% in 1990 (of 1472 adult-plumaged birds). In 1989, 25.1% of 506 adult-plumaged birds captured for banding were blue. In 2006, flying non-breeding birds were counted from photos, resulting in 21.1% blue morph (of 655 birds). Nesting Snow and Ross's geese occupied essentially the same area in the central-western part of the island, totalling approximately 38 km² in June 1988, 31 km² in June 1998, and 36 km² in June 2006 (Figure 2). Snow Goose productivity in 1989, estimated from a sample of 643 adult-plumaged birds plus young geese captured on 9 August, was 47% young. Ground observations in 1990 of 29 groups of goslings and adults tallied 1472 adult Snow Geese, 87 adult Cackling Geese, and 1322 goslings of both species. Assuming the goslings occurred in the same ratio as adults of the two species, there were 1248 Snow goslings, and 46% of the Snows were young.

During ground work on the JLI colony in June 1988 we observed evidence of extensive grazing and grub-



FIGURE 2. Jenny Lind Island, Nunavut, showing area occupied by nesting Lesser Snow and Ross's geese in June 1988, 1998, and 2006, as determined from aerial photography. Landsat 7 image courtesy GeoBase®.

bing in and around the sedge lowland of the central-western part of the island. During banding operations in August 1989 we visited 12 sites throughout the island and observed that virtually all forbs, grasses, and flowering plants had been clipped to near ground level. In general, vegetation on JLI appeared to be retarded and heavily grazed compared to vegetation observed during the previous two weeks in the nearby Queen Maud Gulf Migratory Bird Sanctuary. The relatively small areas of sedge lowland on the island were brown and dry, apparently due to less summer rainfall than usual there. In July 1990, localized destruction of wet tundra habitat was also evident on JLI, with heavily grubbed and grazed areas on the periphery of some ponds, similar to conditions noted by Jefferies et al. (1979) on southwest Hudson Bay. Although this "over-grazed" condition appeared to be localized, most of the sedges and grasses in the wet lowlands had been grazed to some extent by geese.

Discussion

Snow Geese were first reported on JLI by Parmelee et al. (1967), who studied birds on the eastern third of the island in 1962 (19 June to 5 July) and 1966 (31 May to 12 August). They recorded about 70 adult Snow Geese each year, and estimated that the total island population was about 210 adults. Kuyt et al. (1971*) counted 300 adult and 258 young Snow Geese during a 56 km aerial survey of JLI from a Beaver aircraft on 5 August 1971. The counts for 1962, 1966, and 1971 probably reflect minimum numbers of geese present. In any case, 11 years later the island's Snow

TABLE 1. Results of surveys of Lesser Snow and Ross's geese on Jenny Lind Island, Nunavut, 1988, 1990, 1998, and 2006.

Survey date	Total area surveyed km ²	Area sampled km ² (%)	Number of nesting adults	SE	Number with adult plumage ¹	SE	% blue morph	(sample size) ²
June 1988 ³	38.3 ⁴	9.40 (24.6)	39 154 ⁵	2238	42 156 ⁵	2445	19.0	(2595)
July 1990 ⁶	422.0 ⁷	100.8 (23.9)	n/a	n/a	25 020	3114	23.0	(1472)
June 1998 ³	30.6 ⁴	4.44 (14.5)	19 253	2323	20 272	2342	n/a	n/a
June 2006 ³	35.6 ⁴	5.73 (16.1)	21 572	1898	26 422	2663	21.1	(655)

¹ Adult-plumaged birds = nesting birds plus non-breeders.

² Number of Snow and Ross's geese in sample used to estimate % blue morph.

³ Air photo survey of nesting Snow and Ross's geese.

⁴ Area occupied by nesting Snow and Ross's geese.

⁵ Includes an estimated 2.7% Ross's from ground survey in 1988 (see text).

⁶ Visual transect survey from helicopter.

⁷ Total area of Jenny Lind Island.

Goose population was much larger. Robert Decker (Northwest Territories Department of the Environment and Natural Resources, personal communication) estimated that 3000 to 4000 adult Snow Geese were present on JLI on 13 July 1982, during a 125 km visual survey from a Cessna 280 aircraft. Only three years later another major increase was reported by McCormick and Poston (1988). On 9 July 1985, they flew helicopter transects which sampled the entire island during the early brood-rearing period, and obtained the first statistically reliable population estimate for the island: 54 100 (SE = 8 100) adult-plumaged Snow Geese (Figure 3). Ross's Geese were first recorded on JLI in 1988 when 2.7% of the nesting geese were estimated to be Ross's. In the other survey years Ross's were not specifically identified, except for 1998 when T. L. Hoar (personal communication), in a separate study of birds on JLI, recorded 45 adult Ross's and one Ross's nest in the Snow Goose colony.

The rate of increase in Snow Goose numbers was about 34% per annum between 1962-1966 and 1985, and 149% per annum between 1982 and 1985 (Figure 4). That was far too great to be explained by increased reproductive success and survival of Snow Geese hatched on JLI. The increase was probably due to immigration from larger colonies elsewhere, such as those at Queen Maud Gulf Migratory Bird Sanctuary or West Hudson Bay (Kerbes et al. 2006).

JLI Snow and Ross's goose numbers appear to have declined overall since their peak of 54 100 in 1985 (Table 1, Figure 4), as might be expected, given the limited food resources for the geese on the island. Subsequent estimates of adult-plumaged birds were: June 1988 = 42 200 (22% less than in 1985); July 1990 = 25 000 (40% less than in 1988); June 1998 = 20 300 (20% less than in 1990); and June 2006 = 26 400 (30% more than in 1998). It seems that the JLI Snow Goose population peaked in the late 1980s, declined in 1990 and remained at about the 1990 level up to 2006.

The limited amount and quality of food plants on JLI is probably the key factor that caused the popula-

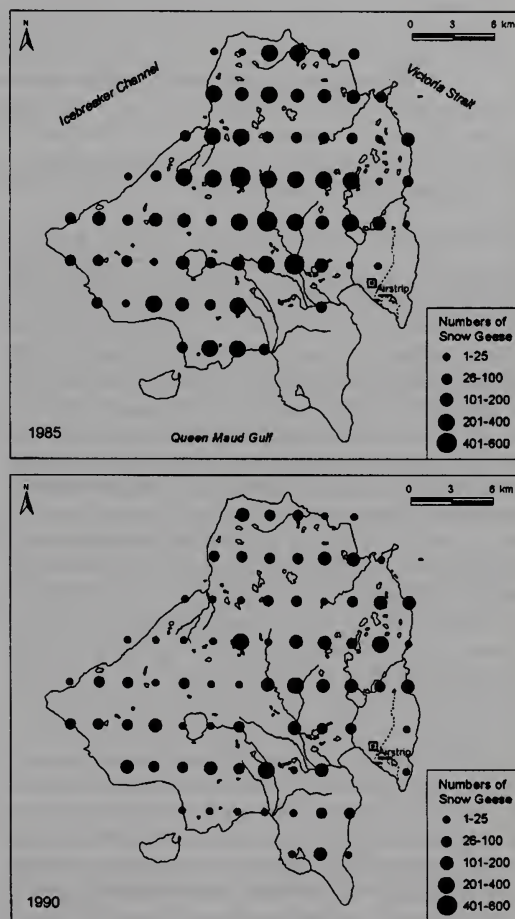


FIGURE 3. Distribution of adult-plumaged Lesser Snow and Ross's geese, per 1.2 km² transect segment from visual helicopter transect surveys, 9 July 1985 (McCormick and Poston 1988) and 28 July 1990.

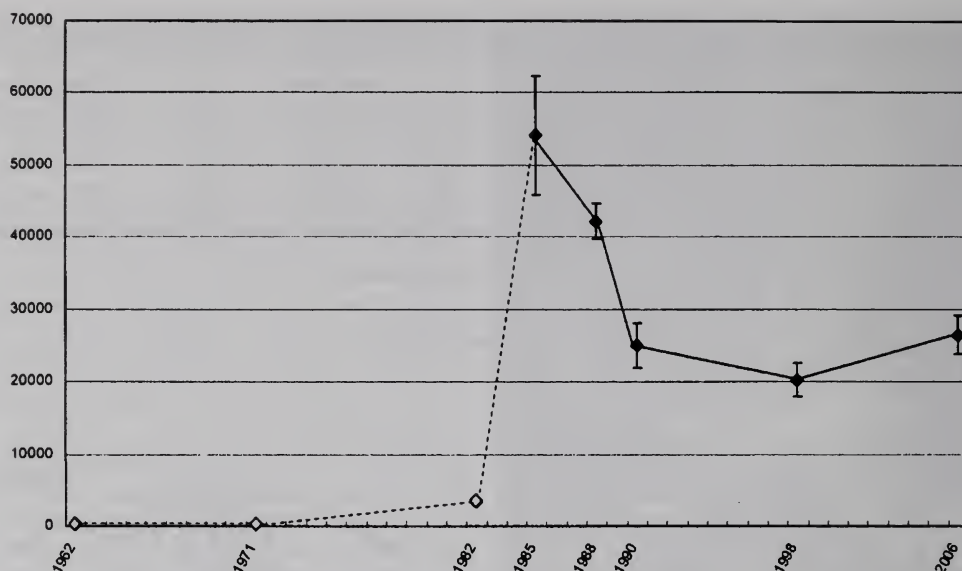


FIGURE 4. Estimated number (\pm SE, for 1985-2006 only) of adult-plumaged Lesser Snow and Ross's geese on Jenny Lind Island, Nunavut, 1962 to 2006.

tion to decline, through decreased survival, lowered productivity, or emigration. Geese were scattered over the entire area of JLI in July of 1985 and 1990 (Figure 3), including areas with little or no vegetation, thus having potential impact on habitat throughout the island. Although we recorded substantial productivity in 1989 (47% young) and 1990 (46% young), we have no information on how successful those young birds were in fledging. During Snow Goose banding operations in 1989, at JLI and QMG, the condition and behaviour of the geese differed remarkably between the two locations. In Queen Maud Gulf Migratory Bird Sanctuary the breeding geese occurred in flocks of families, ranging in size from 50 to several hundred birds each. On JLI most breeding geese occurred as scattered individual families, rather than groups of families, making it difficult to round up a flock of at least 100 for banding. Presumably the low availability of forage caused the high dispersion and low density of feeding geese. The young birds on JLI, although of similar age to those of QMG, were noticeably lighter in weight. Furthermore, both adult and young geese on JLI appeared to be weaker, and the young birds rushed to feed on what little vegetation was available nearby as soon as they were released from the banding pen. That contrasted with the behaviour of young Snow and Ross's geese which we and others (C. D. MacInnes, F. Cooke, R. Alisauskas, personal communication) have observed during arctic banding operations elsewhere. Normally, upon release from the banding pen, both adult and young geese quickly flee rather than attempting to feed.

In 1989 young geese were not banded because they appeared to be weak and underweight, even though

their structural size was normal for their age (approximately four weeks). Nine adult Snow Geese collected in 1990 showed no evidence of unusual nutritional stress (G. Wobeser, Western College of Veterinary Medicine, unpublished pathology report). The average weights of five males ($2267 \pm \text{SE } 128 \text{ g}$) and four females ($2059 \pm 129 \text{ g}$) were similar to those reported by Ankney (1979) for wild birds at the same time of year.

Because JLI is small and sparsely vegetated, overpopulation by geese was expected to lead to destruction of feeding habitats, with serious decline in the condition and numbers of geese. Strong evidence of unusual mortality was not found by McCormick and Poston (1988) in 1985 or in our surveys in 1988, 1989 and 1990. However, at least three anecdotal reports of large die-offs of geese on or near the island in the summers of 1984 and 1985, and in autumn 1989, were received from workers at the DEW Line station or on ships bringing supplies to the station (Kerbes et al. 2005*). They indicated that from hundreds to thousands of geese had died. Although such numbers were unconfirmed, it may be significant that those reports were received during the period when the population grew most rapidly and deterioration in the vegetation caused by over-grazing may have begun to impact the geese on JLI seriously.

On 8 and 9 August 1989, while banding Snow Geese on JLI, we did not observe any evidence of recent mortality. However, on central-eastern and southeastern parts of JLI we observed dried carcasses and other remains of young Snow Geese which apparently had died during the previous year. Similarly, in 1990 scattered remains of a few dead geese from the

previous year were found during ground work. Although we noted only small numbers of carcasses in 1989 and 1990, the actual numbers of geese that had died was probably larger. Mass die-offs can attract avian and mammalian scavengers which reduce the number and visibility of the carcasses (A. J. Erskine and G. Wobeser, personal communication).

It is difficult to accept that the limited food resources of Jenny Lind Island are abundant enough to allow significant numbers of newly hatched young to survive to fledging. Possibly, the persistence of this colony is due solely to immigration from the large and increased numbers of Snow Geese in the QMG region and elsewhere in the Canadian Arctic (Kerbes et al. 2006). Further study of JLI and its geese could provide valuable insights for managing the Midcontinent Snow Goose Population and its arctic habitats. JLI is like an isolated laboratory where newly hatched geese and their flightless parents are "trapped" on an island with a limited and probably dwindling food supply. It offers a good opportunity to evaluate the interactions of geese and their habitat and the resilience of both the goose populations and their habitat. We recommend continued monitoring of the numbers of the Snow and Ross's geese there, a general habitat survey with detailed ground studies of the vegetation, and banding of the geese to determine body condition, survival rates, and, possibly, levels of immigration.

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Repeatability of Foraging Tactics in Young Brook Trout, *Salvelinus fontinalis*

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In this study, we repeatedly observed individually marked Brook Trout in a field setting to determine if the bimodal variation in foraging tactics previously observed in young salmonid populations (without distinct morphological differences) is generated by individuals specializing at different foraging tactics. We found significant but low repeatability in several foraging movement parameters. This indicated that while individuals did have tendencies to be sedentary versus highly active, there was considerable variation in foraging activity within individuals. These results suggest that relatively consistent differences among individuals may facilitate selection for specialized morphology and that there may be a heritable component to activity.

Key Words: Brook Trout, *Salvelinus fontinalis*, juveniles, behaviour, foraging, activity.

Recent reviews suggest that between-individual variation in behaviour, and behavioural specialization of individuals, may play an important role in the evolution of resource polymorphisms (divergent specialization on food resources) and ecological speciation (Skúlason and Smith 1995; Schluter 1996; Wilson 1998; Bolnick et al. 2003; Sih et al. 2004). Many good examples of divergent foraging behaviour and morphologies exist, particularly among fish populations (Robinson and Wilson 1994; Bolnick et al. 2003). However, most studies focus on fish species where morphological differences exist and so it is difficult to assess whether behavioural diversification preceded or followed morphological differences (Futuyma and Moreno 1988; McLaughlin et al. 1999). Behavioural diversification is believed to be an important initial step in the development and evolution of resource polymorphisms prior to their reinforcement by morphological differences (McLaughlin and Grant 1994; Wimberger 1994; Skúlason and Smith 1995; McLaughlin et al. 1999). Indeed, habitat-specific competition for food has been shown to promote divergent foraging behaviour in young charr [trout] without morphological differences, resulting in two foraging tactics with similar growth potential (McLaughlin et al. 1999). Similar growth potential may stem from differences in growth efficiencies and prey profitability of Brook Trout, *Salvelinus fontinalis*, occupying different habitats (Morinville and Rasmussen 2003). Now, if morphology is plastic, then behavioural specialization (repeatable differences among individuals) may promote specialized morphologies that increase foraging efficiency. If behavioural specialization precedes morphological differentiation, then it should be possible to find examples of repeatable

differences in foraging tactics in natural populations without distinct morphotypes. However, few studies have quantified the degree to which individuals are specialized relative to their population (Bolnick et al. 2003). To our knowledge, no study has directly quantified repeatability in foraging behaviour in a species where distinct foraging tactics exist in the absence of corresponding morphological differences, nor have any of the studies of behavioural variation in salmonid fishes quantified repeatability in behaviour.

This study fills this gap in our understanding of the existence and extent of behavioural specialization by examining the repeatability of foraging behaviour in a lake-dwelling population of young Brook Trout. Previous work in lakes has revealed bimodal variation in foraging activity of young Brook Trout, with most individuals adopting either sedentary (ambush) or highly active (pursuit) foraging tactics (Biro and Ridgway 1995; Biro 1996; Biro et al. 1997). These differences in foraging activity affect the type and rate of prey encounter by young Brook Trout and their foraging success (Biro and Ridgway 1995; Biro et al. 1996). Therefore, the aim of this study is to determine whether behavioural specialization of divergent foraging tactics exists as a potential mechanism for promoting morphological divergence in a system where no known morphological differences exist.

Methods

Study site

Scott Lake is a small lake (surface area 27 ha) with good visibility (secchi disc depth 6 m) located in Algonquin Provincial Park, Ontario, Canada. We constructed two field enclosures along a portion of the

TABLE 1. Body size and mass of young Brook Trout at time of stocking into each enclosure at Scott Lake.

Body size measures	Enclosure	Mean	Range	S.E.	n
Total length (mm)	1	29.6	28.0 – 32.0	0.75	5
	2	29.4	28.0 – 31.0	0.51	5
Weight (g)	1	0.17	0.13 – 0.24	0.019	5
	2	0.15	0.13 – 0.18	0.008	5

shoreline that had a combination of inundated shoreline vegetation, woody debris, and relatively open areas which are typical of areas inhabited by Brook Trout (Biro et al. 1997). Enclosures were built using beach seine mesh (6 mm openings) and supported with steel rods such that it enclosed a 5 m length of shoreline and extended from 2 to 3 m offshore. The mesh extended 20 cm above the surface of the water. This design allowed a single observer (PAB) to enter at one end of the enclosure to perform snorkelling observations, at distances that did not appear to disturb the fish; maximum depth of the enclosures was 1 m. The enclosure design also allowed fish to access natural benthic organisms, nearshore terrestrial insects and Collembola (springtails) common in their diet (unpublished data); mesh size was a compromise between minimizing the exclusion of zooplankton from the enclosure while also containing these small fish. A pilot study the previous year indicated that an enclosure of this size did not restrict the movements of fish and was not so large as to create difficulties in finding individuals within and among shoreline vegetation and debris.

Selection and marking fish

Twenty YOY (Young-of-the-Year) Brook Trout were sampled using large aquarium dipnets from nearshore habitats while snorkelling in Scott Lake and brought back to the laboratory where they were anaesthetized using tricane-methane sulfonate (MS-222), weighed (± 0.01 g), measured (total length ± 1 mm), individually marked for identification and kept overnight in aerated lake water. Marks were given by cauterizing tiny (<0.5 mm) holes in their fins using different fins and locations within a fin to achieve unique identification for each individual (McNicol and Noakes 1979). Our method differed only in that we placed and branded each fish on a flat sheet of Teflon which prevented the fin from burning onto the branding surface. Two fish which were in poor condition and several which had torn fins were discarded. Subsequently, we stocked five fish of similar size and in good condition in each enclosure (Table 1). There was no indication that the marks affected their swimming performance. Neither body length ($t = 0.22$, $P < 0.83$) nor weight ($t = 0.95$, $P < 0.36$) of fish differed significantly between the enclosures. Fish were allowed to acclimatize for one more full day before behavioural observations began.

Behavioural observations

We observed Brook Trout between 0945 and 1530 hours from 14 to 21 May, three weeks after swim-up

from spawning redds. The experiment was terminated on 22 May [after eight days] because water levels rose more than 35 cm and flooded the enclosures and fish escaped. We attempted to observe each uniquely marked individual twice each day, once between 0945 and 1130 and again between 1300 and 1530. All of the marked fish (some outside of the enclosures) were recovered on the morning of 22 May to obtain body weight (wet weight ± 0.01 g), and length (total length ± 0.5 mm).

Observations were made using mask and snorkel and recorded by a second observer floating nearby. Fish were observed at a distance of about 1 m away, and the magnifying effect of the mask underwater made individual fish marks clearly visible. A fish that was near one end of the enclosure was chosen first for observations. The observer then moved across the enclosure selecting as many new individuals to observe as possible along the way. The observer lay motionless for several minutes to ensure the fish was not disturbed and was feeding. The number of body lengths traveled by each fish and behavioural events were then called out through the snorkel during alternating 5 sec intervals according to established methods (Biro and Ridgway 1995; Biro et al. 1996, 1997). Intervals that did not include forages or agonistic behaviour were considered intervals of search, while intervals including forages were called pursuits (McLaughlin et al. 1992; Biro and Ridgway 1995). Forages were defined as the capture of a potential prey item (Biro et al. 1996). The proportion of search time spent moving was calculated as the proportion of observation intervals where the focal fish moved one body length or more (McLaughlin et al. 1992; Biro and Ridgway 1995). Although agonistic behaviour was recorded, it is a rare occurrence for this species in small lakes (Biro and Ridgway 1995; Biro et al. 1997) and was not considered further. In general, fish that spend a greater proportion of search time moving also move faster and pursue prey further than fish that are less active (McLaughlin et al. 1992; Biro and Ridgway 1995). We did not quantify actual foraging rates or success in this study because the positive relationship between feeding rates and activity is very well established in this lake and another lake with large sample sizes (Biro and Ridgway 1995; Biro 1996; Biro et al. 1996).

Statistical analyses

Univariate statistics are presented using raw data unless otherwise indicated. To meet the required assumptions for parametric statistical tests, the proportion of

TABLE 2. Back-transformed mean and range in the proportion of search time spent moving for each individual Brook Trout in the two enclosures at Scott Lake. The number of repeated observations on each fish (n) and number of days over which the observations took place are given.

Fish	Mean	Range	n	Days observed
1	0.36	0.03 – 1.0	9	6
2	0.44	0.0 – 1.0	9	6
3	0.52	0.14 – 0.95	5	4
4	0.65	0.38 – 0.88	9	5
5	0.66	0.21 – 1.0	9	4
6	0.73	0.0 – 1.0	6	5
7	0.82	0.33 – 1.0	10	6
8	0.91	0.17 – 1.0	9	5
9	0.91	0.50 – 1.0	9	6
10	0.92	0.64 – 1.0	4	3

TABLE 3. Repeatability (R) and corresponding one-way ANOVA results on the foraging movement parameters based on repeated measurements on known individuals. Degrees of freedom (df) are given in parentheses.

Movement parameter	R	MS_{among}	MS_{within}	F-ratio	P
Proportion of time spent moving	0.168	0.393 (9)	0.151 (70)	2.6	0.012
Average search speed	0.143	0.634 (9)	0.275 (70)	2.3	0.025
Speed while moving during search	0.161	0.271 (9)	0.109 (68)	2.5	0.017
Pursuit distance	0.308	0.522 (6)	0.116 (67)	4.5	0.0001

time spent moving was arcsine-square-root transformed, speed while moving was square-root transformed and average search speed was $\log(x + 1)$ transformed. The repeatability of measures of foraging activity were assessed by calculating the coefficient of intraclass correlation (or simply, repeatability (R)). Repeatability is the proportion of variance that occurs among, rather than within individuals, calculated from a simple single-factor ANOVA for unequal sample sizes (Lessells and Boag 1987). As the proportion of among individual variance (R) increases in magnitude, the relative within individual variance declines. Examination of repeatability is informative because it combines both heritable and environmental components and therefore sets an upper limit for heritability (Falconer 1981).

Results

Young trout activity ranged from quite sedentary to highly active among individuals, with mean individual time spent moving ranging from 0.36 to 0.92 (Table 2). There was wide variation in activity within individuals whereby even the most sedentary individuals were on rare occasion moving continuously (Table 2). Nonetheless, there was significant repeatability in all measures of foraging activity (Table 3). The proportion of search time spent moving, speed while moving during search, and average search, speed had significant but relatively low repeatability. In contrast, distance moved in pursuit of prey had moderate repeat-

ability (Table 3). Estimates of repeatability, while generally low, indicate some degree of specialization whereby active individuals tended to remain active and sedentary individuals tended to remain sedentary (Table 2).

Substantial growth was observed during the course of the experiment confirming successful foraging and presence of natural food in the enclosures. Brook Trout increased significantly in terms of total body length (mean difference = 5 mm, paired $t = 11.9$, $P < 0.000001$, $n = 10$) and mass (mean diff. = 0.20 g, paired $t = 18.8$, $P < 0.00001$, $n = 10$), thus doubling their mass on average. However, fish that spent a greater proportion of time moving did not grow any faster or slower than more sedentary fish, either in terms of gain in length ($P > 0.20$) or weight ($P > 0.20$).

Discussion

We found evidence of significant repeatability in several measures of foraging movements for young Brook Trout. However, repeatability was low indicating that while individual fish can be characterized by their relative level of foraging activity, there was considerable variance in activity levels within individuals. In other words, the majority of the observed variance in foraging activity was accounted for by within-individual variability in activity. Therefore, the bimodal variation in the proportion of time spent moving observed previously in lake-dwelling populations of Brook Trout (Biro and Ridgway 1995; Biro 1996)

appears to be generated by individuals with highly variable, but repeatable differences in foraging activity. For example, when all observations from the present experiment are pooled, the frequency distribution of the proportion of time spent moving does not differ from a large survey of different individuals in Scott Lake in 1994 (Biro 1996; Kolmogorov-Smirnov test, $D_{\max} = 0.07$, $P < 0.0001$, $n_{\text{enclos}} = 79$, $n_{\text{survey}} = 111$). The significant repeatability of foraging tactics observed within this young Brook Trout population exhibiting behavioural divergence (without morphological divergence) supports the hypothesis that behavioural divergence precedes morphological divergence in the evolution of resource polymorphisms and ecological speciation (Wimberger 1994; Skúlason and Smith 1995; McLaughlin et al. 1999).

It should not be too surprising that repeatability for foraging movement parameters are low when observation duration is but a small portion of total time spent foraging and behavioural flexibility is so well documented. One would expect that even the most sedentary individuals must spend time being active to find foraging locations that lend themselves to an ambush type of foraging tactic. The observed moderate repeatability in pursuit distance may reflect specialization of active individuals towards prey items located on the surface. Individuals spending more time active, and pursuing prey further have higher surface foraging rates than less active individuals (Biro and Ridgway 1995; Biro 1996; Biro et al. 1996). Individuals with moderate specialization in pursuing prey over greater distances are likely chasing down relatively large prey items that have fallen to the surface or are emerging from the surface as shown for young Brook Trout in Scott Lake (Biro 1996) and another lake (Biro and Ridgway 1995; Biro et al. 1996). By contrast, those individuals adopting a more sedentary foraging tactic tend to feed on plankton and benthic invertebrates emerging from the bottom (Biro 1996; Biro et al. 1996).

Observing repeatable differences in foraging behaviours suggests that there is a heritable component to them (e.g., Falconer 1981). If so, then behavioural specialization, in combination with morphology that can change adaptively according to activity levels (Imre et al. 2002) and prey types (Skúlason and Smith 1995; Smith and Skúlason 1996) can provide the basis for further specialization possibly leading to the evolution of resource polymorphisms as suggested for other charr species (Skúlason and Smith 1995). Genetically based differences in activity among individuals in this population should be expected given that intrinsic growth rates (IGR), activity levels and aggressiveness are all positively correlated in salmonid fishes, and growth rate has high variance and heritability (e.g., Gross 1998; Gjedrem 2000). In addition, there has been a recent increase in our appreciation of the extent of repeatable differences in behaviour in a variety of animals, termed behavioural "syndromes" and "person-

ality" (Sih et al. 2004). As Sih's review points out, more field studies are needed to uncover the extent to which repeatable differences in behaviour exist, and their stability over time and across situations. A comparison of bioenergetics between resident and anadromous stream Brook Trout revealed a much higher metabolic rate for the anadromous form and therefore a greater likelihood of habitat switching (i.e., anadromy) for the anadromous form (Morinville and Rasmussen 2003). Fundamental differences in quantitative traits such as metabolic rate may be important factors contributing to bimodal variation in foraging activity.

Bimodal variation in activity, whereby relatively few individuals have intermediate levels of activity, suggests specialization on distinct prey fields that favours alternate foraging tactics. Recent work on Brook Trout in stillwater pools in streams suggests that this is the case, and results in two foraging tactics with similar growth rates for individuals specializing on benthic versus pelagic prey items (McLaughlin et al. 1999; McLaughlin 2001). The present study supports this hypothesis given the equal short-term growth rates among individuals with different activity tendencies. However, there was considerable variability in activity within individuals that were observed over a relatively short time span, and this coupled with small sample sizes reduces considerably the power to detect any relation between foraging tactics and growth rates.

A speculative alternative hypothesis suggests that, like Rainbow Trout (*Oncorhynchus mykiss*), young Brook Trout have a genetic basis to IGR and activity levels such that those with higher IGR are more active in search of food and experience higher growth rates, but have elevated predation mortality (Werner and Anholt 1993; Biro et al. 2004). If so, then perhaps the tradeoff between growth and mortality rates favours individuals with low activity (low growth, high survival) and individuals with high activity (high growth and mortality) if frequency-dependent selection against intermediates is high. Indeed, there are good reasons to expect that there is a cost to switching between prey types, and for generalist feeding strategies (discussed in McLaughlin et al. 1999). At a minimum, greater consideration of the role of predation risk in the evolution of resource polymorphisms and ecological speciation will further our understanding of the extent and ecological implications of behavioural variation that has traditionally focused exclusively on competition for resources (but see Vamosi and Schluter 2002). Finally, it seems that further study of the mechanism(s) responsible for widespread behavioural variation within and among populations will greatly aid our understanding of important ecological processes.

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Use of Winter Dens by Porcupines, *Erethizon dorsatum*, in Wisconsin

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Porcupine (*Erethizon dorsatum*) dens were monitored in Sandhill Wildlife Area in central Wisconsin between 1996-1997 and 2002-2003 to determine whether they displayed fidelity. Fidelity declined between years, with a higher proportion of Porcupines displaying fidelity to a specific den within a single winter than between winters. Yearlings displayed higher fidelity to den sites than adults. Fidelity was stronger among Porcupines occupying rock vs. tree dens. Familiarity with home spaces and onset of snowfall and snowfall depth also probably influence selection of dens.

Key Words: Porcupine, *Erethizon dorsatum*, winter, dens, denning behavior, den-site fidelity, Wisconsin.

The North American Porcupine's range extends throughout temperate and arctic regions of the continent; they are the most cold-adapted members of the family Erethizontidae (Roze 1987; DeMatteo and Harlow 1997). Porcupines inhabit highly seasonally productive environments, and they have developed physiological and behavioral adaptations for surviving the lean winter months (Clarke and Brander 1973; Roze 1987, 1989; Sweitzer and Berger 1993; DeMatteo and Harlow 1997).

Porcupines sometimes occupy dens as a behavioral strategy to cope with stresses in winter months (Roze 1987, 1989). Porcupines in Massachusetts generally den from October-November to April (Roze 1987, 1989; Griesemer et al. 1996; Griesemer et al. 1998). Porcupines in Roze's study exhibited denning behavior when temperatures were below 0°C in the presence of snow cover (Roze 1989). Roze (1989) suggested denning aided in thermoregulation. Indeed, Zimmerling (2005) presented evidence of thermoregulatory benefits to Porcupines denning within stumps and rock crevices.

Roze (1987) examined time periods, number of individual dens, and relative gregariousness of denning Porcupines as it relates to winter foraging. On average, animals changed dens every 23 days and shared dens 12% of the time. Porcupines in his study showed strong year-to-year den fidelity (Roze 1987). Zimmerling and Croft (2001) analyzed Porcupine selection of winter dens based on the distribution of selected local forage and reported an average of 1.75 Porcupines per winter den. Griesemer et al. (1996) reported 2 to 4 Porcupines using individual dens within a single mild winter but this dropped to 2.0 to 2.8 during a more severe winter, implying that winter weather influences the number of dens used by Porcupines during any single winter.

The present study summarizes den use by Porcupines studied in central Wisconsin between winters 1996-1997 and 2003-2004. Specifically we investi-

gated whether resident Porcupines exhibited fidelity to individual dens, by measuring occupancy rates of dens within and between winters in our study area.

Methods

Porcupines were studied during eight consecutive winters (1996-1997 to 2003-2004) on the 36 km² Sandhill Wildlife Area (SWA) located in southwest Wood County, Wisconsin. Descriptions of SWA physiography and den search methods are provided by Natzke and Thiel (2007). Dens in this study included living hollow trees (tree dens) and rock talus (rock dens).

Dens were visited at irregular intervals each winter. We recorded den number, date, time, whether active and currently occupied at the time of each inspection. If the den was occupied the Porcupine was captured in a box trap, sedated using Telezol after Hale et al. (1994), and handled following protocols established by Wisconsin Department of Natural Resources Animal Care and Use Committee. Porcupines were sexed and aged as juvenile, yearling, or adult based on molariform dental eruption patterns (Kochersberger 1950). Each Porcupine was ear tagged, and beginning in 1998-1999, a passive integrated transponder tag (PIT) (©AVID Identification Systems, Inc.) was injected subcutaneously between the shoulder blades to uniquely identify it. In 1999 Porcupines captured in traps were scanned for the presence of a PIT tag and if identified, were weighed and released in the field. Thus data on each Porcupine included the den it occupied.

We define fidelity as an individual Porcupine occupying a single den over the specified period. The number of dens used by individual Porcupines and the number of Porcupines using an individual den were analyzed using three time periods: within a single winter, two consecutive winters, and three-consecutive winters. Permutations were used when analyzing the two-consecutive winter and three-consecutive winter periods. For instance, den G-6 was active in 1996-1997

through 2001-2002, and in 2003-2004. For the six-year period 1996-1997 through 2001-2002, we were able to use six permutations for the two-consecutive winter analysis, and five permutations for the three-consecutive winter analysis.

Results

An unknown but small number of marked Porcupines were not known to use winter dens. Dates Porcupines commenced using winter dens in autumn and abandoned winter dens in spring varied from year to year, and by individual Porcupine. Generally, denning behavior commenced in mid-November, and a majority of Porcupines were occupying dens by early December. Dens were abandoned in mid- to late March, although some use occurred sporadically into early April. A few individual Porcupines used dens occasionally throughout the summer. In most years, winter dens were occupied over a period of approximately 110 days.

We monitored 56 tree dens used by at least 49 individual Porcupines, accumulating 98 tree den-years of data. Only three tree dens were known to be occupied by two Porcupines simultaneously. Rock dens used in this analysis were limited to two talus slopes occupied by six individual Porcupines. Unlike tree dens, rock dens frequently housed more than one Porcupine.

In any single winter 66 percent of our monitored tree dens were active. Ten tree dens with data spanning six consecutive winters averaged 2.45 winters of active use by Porcupines. Fifteen percent were active in only a single winter, 50 percent in two winters, 20 percent in three winters, 10 percent in four winters, 0 percent in five winters, and six percent in six winters.

Among active tree dens monitored for a single winter, 84 percent ($n = 47$) were occupied by a single Porcupine, and 16 percent ($n = 9$) by two different Porcupines. For tree dens monitored over two consecutive winters, 26 percent were occupied by only one Porcupine ($n = 15/58$) and 74 percent ($n = 43/58$) by two individual Porcupines. For tree dens monitored three consecutive winters, 20 percent ($n = 4/20$) were occupied by a single Porcupine, 45 percent ($n = 9/20$) by two porcupines, 15 percent ($n = 3/20$) by three Porcupines, and 20 percent ($n = 4/20$) by four Porcupines.

A mean of 1.2 Porcupines occupied each active tree den in single winters, 1.7 Porcupines per tree den over two consecutive winters, and 2.35 Porcupines per tree den over three consecutive winters. Differences between these means were significant (t-test, df: year 1 = 55; year 2 = 57; year 3 = 19, $P < 0.001$).

Data on the relative fidelity of Porcupines occupying tree dens was obtained from 46 individual Porcupines. Individual Porcupines averaged 1.3 dens used per single winter, 1.8 tree dens over two consecutive winters, and 2.1 dens per individual Porcupine over three consecutive winters. Differences between these means were significant (t-test, df: year 1 = 53; year

2 = 30; year 3 = 11, $P < 0.001$). By comparison, individual Porcupines ($n = 6$) used an average of 1.05 rock dens per single winter, 1.2 rock dens over two consecutive winters, and 1.3 rock dens over three consecutive winters, but samples were too small to perform any statistical tests.

Fidelity to tree dens within a single winter was analyzed by gender and by age group. There was no significant difference between males and females (81 vs. 66 percent) that displayed fidelity to dens ($\chi^2 = 1.49$; df = 1, $P \leq 1$). Juveniles and yearlings displayed significantly higher fidelity than adults (91 and 100 vs. 58 percent) ($\chi^2 = 7.56$, df = 1, $P \leq 0.01$).

Among individual Porcupines monitored in tree dens ($n = 20$), 75 percent ($n = 34/45$) displayed fidelity to a single tree den site in the single winter period, 35 percent ($n = 11/31$) over two consecutive winters, and 17 percent ($n = 2/12$) in the three consecutive winter period. Among individual Porcupines monitored in rock dens ($n = 6$ Porcupines) 94 percent ($n = 17/18$) displayed fidelity to a single rock talus site in the single winter, 78 percent ($n = 7/9$) in the two-consecutive winter periods, and 67 percent ($n = 4/6$) in the three-consecutive winter periods.

Fidelity to den site during a single winter was significantly higher for Porcupines occupying rock talus vs. tree dens ($\chi^2 = 4.5$; df = 1, $P \leq 0.05$). In both tree and rock dens, fidelity to den site decreased significantly between single winters and the three-consecutive winter periods ($\chi^2 = 22.22$; df = 3, $P \leq 0.001$).

Discussion

Winter denning behavior is not uniformly observed throughout the Porcupine's range. Oveson (1983) and Stricklan (1987) rarely observed Porcupines utilizing dens in their mountainous Utah study areas. Sweitzer and Berger (1992, 1993) and Sweitzer (1996) did not mention Porcupine use of winter dens in their Nevada studies. Stricklan (1987) observed that Porcupines in his Utah study area moved from roost to feed trees throughout the winter and their only attempt at thermoregulating was to orient their backs to the sun.

Zimmerling and Croft (2001) determined that den site selection in their British Columbia, study area was influenced by proximity to highly preferred tree forage species. Selection of dens based on the distribution of preferred forage likely does not exist in SWA because Porcupines in our study area show little or no foraging preferences (Thiel, unpublished data). Porcupines in the areas of Massachusetts studied by Griesemer et al. (1996) displayed little or no fidelity, but they did demonstrate that the number of Porcupines utilizing individual dens was related to the harshness of the winter. Fidelity displayed by resident Porcupines is likely affected by factors such as the number of suitable den sites within respective home ranges, competition for dens by other Porcupines (likely density-dependent) and other cavity-dwelling species,

the age structure of the Porcupine population, and Porcupine longevity.

Porcupine densities increased steadily from 2.5 Porcupines/km² in 1998-1999 to 4.7/km² in 2002-2003 (Thiel, unpublished data). Surveys conducted in 1998-1999 indicated that only 41 percent of tree cavities ($n = 9/22$) capable of housing a Porcupine were active that winter. Porcupine densities we observed did not affect availability but by 2002-2003 some competition for dens was likely, due to a doubling in the Porcupine population.

Limited radio-telemetry data (2 males: 4 females) indicate that a mean of 3.5 dens (range: 1-6) were found within individual Porcupine home ranges (size: mean = 64.8 hectares; range: 28-137 hectares), nearly twice the number actively used by Porcupines in an average winter (Thiel, unpublished data). Either dense fidelity is operative or reduced mobility with the onset of snow limits access to distant den sites. We suspect the latter as snow cover is known to restrict winter movements and foraging (Roze 1987; Sweitzer 1996; Griesemer et al. 1996).

Porcupines do compete for winter den sites. We witnessed numerous instances where Porcupines "swapped" dens but we were unable to determine how much our trapping activities influenced this behavior. In several instances when we released a Porcupine 24 h after capture, we discovered its den was already occupied by another. We also witnessed several instances of Raccoons (*Procyon lotor*) unsuccessfully and successfully usurping dens while Porcupines were presumably foraging nearby. In these events, Porcupines were forced to seek alternative den sites which thus increased the number of dens used, obscuring den-site fidelity of those Porcupines that may be displayed by other Porcupines.

Yearling Porcupines seemed to show stronger fidelity than adults to a single den. Only two of seven (29 percent) adult Porcupines showed fidelity to a single den within a single winter period. In contrast three of four yearling Porcupines (75 percent) showed fidelity to a single den within the single winter period. Porcupines usually disperse and form home ranges as yearlings (Roze 1987). We speculate that yearlings may not be fully aware of potential den sites because they are probably less familiar with their newly established surroundings than are long-term resident adults.

Porcupine longevity has not been well studied (Earle and Kramm 1980). Presumably, the longer an animal lives and remains confined to a discrete living space (home range), the greater its familiarity will be with local resources, including den sites. Such animals will be in a better position to select and compete for a site best suited to their needs. Porcupines in our study area display impressive longevity: viz. 4 of 13 animals (31 percent) captured in the initial winter of tagging (1996-1997) were still present in the population eight winters later in 2004-2005. Given the longevity we

witnessed, we would have expected Porcupines to display greater fidelity to den sites than they did. The number of dens occupied by individual Porcupines, and the number of individual Porcupines occupying single dens increased over subsequent winters. Despite this, three female Porcupines displayed fidelity to a specific den site that lasted 4, 6 and 8 years.

We agree with Roze (1987, 1989) that Porcupine use of dens is a behavioral strategy used to enhance survival during winter when cold temperatures and poor nutrient diet place great physiological stress on individuals. Over-winter mortality caused by starvation and predation in non-denning Porcupines studied in Nevada and Utah (Oveson 1983; Stricklan 1987; Sweitzer and Berger 1992, 1993; Sweitzer 1996) is as significant as over-winter starvation by denning Porcupines observed in Massachusetts by Hale and Fuller (1996) and in our study area (Thiel, unpublished data).

In our study area the urge to den each winter is strong. Occupancy of winter dens is influenced by age, availability and mostly interspecific competition. Fidelity to specific dens is strongest in young Porcupines and among Porcupines occupying rock talus. While individual Porcupines exhibit den preferences, the species does not display strong fidelity to single dens. It is our observation that in winters with little snow cover, Porcupines forage extensively. In winters with deep snow, their movements are restricted and this may restrict their choice of den sites. We agree with Roze (1987, 1989) that denning behavior is a strategy used by Porcupines to enhance over-winter survival. Further work is needed to understand more fully this aspect of Porcupine ecology.

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Wolf, *Canis lupus*, Den Site Selection in the Rocky Mountains

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Because mortality of Wolves, *Canis lupus*, is highest during the first six months of life, den site selection may affect reproductive success of Wolf populations. We studied fine-scale denning habitat selection (within 100 m of den site) by comparing field-measured characteristics of 22 dens in Idaho, Montana, and Alberta with 22 paired random contrast locations within pack home ranges. In order of importance, Wolves denned in areas with greater canopy cover, hiding cover, herbaceous ground cover, and woody debris, and were closer to water than paired random sites. Thus Wolves may select den sites for physical protection and available water. We also studied coarse-scale denning habitat selection by comparing 35 Wolf dens with 35 paired contrast locations in Idaho, Montana, and Wyoming with respect to six remotely-sensed variables (elevation, slope, coniferous forest cover, solar radiation, distance to water, and distance to roads). Although these variables did not differ (univariate $P > 0.10$) between den and contrast locations, a Mahalanobis-distance model using four remotely-sensed variables (slope, elevation, coniferous forest cover, and solar radiation) suggested $> 85\%$ of dens would occur in potential denning habitat occupying $< 12\%$ of the Wolf recovery areas in the northern Rocky Mountains. This model may be useful for identifying likely den locations in areas not yet occupied by Wolves. Wolf core use areas, including den areas, showed higher intensity of use throughout the year when compared to the entire territory.

Key Words: Wolf, *Canis lupus*, den, modeling, reproduction, selection, Montana, Idaho, Wyoming, Alberta.

Numerous studies have focused on Wolf, *Canis lupus*, reproduction and denning (e.g., Mech 1970; Ballard and Dau 1983; Fuller 1989; Ciucci and Mech 1992; Matteson 1992; Unger 1999), but den site selection in forested ecosystems is not completely understood (Norris et al. 2002). Because most pup mortality occurs within the first six months, site selection and activity around the den can affect reproductive success of the pack (Harrington and Mech 1982).

Wolf population numbers and distribution have increased in the Northern Rocky Mountains since reintroductions in central Idaho and Yellowstone National Park in 1995 and 1996 (U.S. Fish and Wildlife Service et al. 2006). Den site selection by recolonizing Wolves may reflect selection for habitat characteristics relatively unconstrained by tradition, territorial interactions, or other social factors. Habitat models using data collected on a recolonizing population can be used to suggest important factors in den site selection.

Wolf territories in the Northern Rocky Mountains average over 500 km² (U.S. Fish and Wildlife Service et al. 2006), with activities concentrated in the den area during April-June. There are no previous reports assessing the importance of denning areas during the other 9 months of the year. If den areas are important year-round, den locations may be useful for prioritizing areas for management attention.

Our effort is the first to address Wolf den site selection in the northern Rocky Mountains since the reintroductions and is based on a larger number of dens than previous published studies of Wolf den site selection in North America (Ballard and Dau 1983; Ciucci and Mech 1992; Matteson 1992; Unger 1999; Norris et al. 2002). Our objectives were to (1) describe characteristics of den sites used by Wolves; (2) investigate factors influencing den site selection; (3) develop a predictive model of suitable den site habitat throughout the northern Rocky Mountains based on remotely-sensed data; and (4) examine location of den sites relative to home range boundaries.

Methods

Study area

This study was focused in the three United States northern Rocky Mountains Wolf recovery areas: Northwestern Montana, central Idaho, and Greater Yellowstone Area. The northern Rocky Mountains extend from northwestern Wyoming to the northern borders of western Montana and Idaho. This mountain range is bounded by the Great Plains to the east and the Columbia Plateau and Great Basin to the west. Volcanic activity has been the major factor forming these mountains (Kershaw et al. 1998). Receding glaciers have smoothed plains, cut broad valleys, and formed

dramatic peaks. Some of the highest peaks include Gannett Peak in Wyoming (4 207 m), Granite Peak in Montana (3 904 m), and Borah Peak in Idaho (3 861 m). Because of the dramatic change in elevations and latitude, climate varies widely across the study area. Each of the three recovery areas exceeds 50 000 km² and is composed primarily of public lands. Primary ungulate prey of Wolves in this region include Elk (*Cervus elaphus*), White-tailed Deer (*Odocoileus virginianus*), Mule Deer (*O. hemionus*), and Moose (*Alces alces*).

Den site characteristics

Known and probable den site locations were provided by the Nez Perce Tribe in Idaho, the U.S. Fish and Wildlife Service in Montana, and Banff National Park in Alberta, Canada. Dens were found by evaluating aerial telemetry locations of collared wolves during the denning season (April-June). Probable den sites were integrated into the study only after ground crews were able to locate the dens and confirm recent Wolf use. We focused on investigating dens used since 2000. To reduce impact to Wolves, data were collected after aerial and ground telemetry of collared Wolves confirmed the pack was no longer using the den area. Because Wolves often use the same den in subsequent years (Ballard and Dau 1983; Mech and Packard 1990), we took precautions not to modify the den. We collected data at 22 dens (12 in Idaho, 8 in Montana, and 2 in Banff National Park, Canada), excluding dens that were last used before 2000, or dens where habitat modifications had occurred after the den was used by Wolves.

During June-October 2003, we measured 14 vegetative and topographic variables at den and contrast locations (Table 1). Data were collected at den *sites* (a 20 × 20 m plot centered on the den opening) and at den *areas* (the average of variables measured at 5 plots: one at the den opening and one each 50 m from the den opening in the cardinal directions). Hiding cover was recorded as the average percentage obscured of a 2 m cover pole observed from 15 m away in each cardinal direction (Griffith and Youtie 1988). Canopy density was estimated using a spherical densitometer (Lemon 1957).

Fine-scale habitat selection using field-collected data

For each den, we measured the same variables at a random contrast location within the home range of the pack. Home range boundaries were provided by the Idaho and Montana Wolf projects and Banff National Park and consisted of Minimum Convex Polygons based on radio-telemetry data. In some cases, where pack territories appeared stable from year to year and annual numbers of aerial radio locations were low, pack boundaries were based on radio locations pooled over several years (Ballard et al. 1987). For three packs for which home range data were not available, we chose a contrast site 1 km from the den in a random direction.

We compared den and contrast sites and areas using Wilcoxon's signed-ranks test (Zar 1999) for the 13 continuous variables and using Chi-square for presence of water within 100 m (the only categorical variable). Variables significantly different ($P < 0.10$) between den and contrast sites, and den and contrast areas were evaluated for multicollinearity. If Pearson Correlation (Zar 1999) coefficients indicated correlation ($|r| > 0.50$), variables with higher P -values were removed from the list of candidate variables. We created forward entry logistic regression models at the site (1-plot) and area (5-plot) scales. The criterion to enter and retain variables in the logistic regression model was $P < 0.20$ (Hosmer and Lemeshow 2000), using P -values associated with each variable's R statistic.

Coarse-scale habitat selection using remotely-sensed data and developing a predictive model of suitable den site habitat

Remotely-sensed data were available for the 20 dens in the United States at which we collected field data and an additional 15 den locations in Yellowstone National Park (YNP), for a total of 35 dens in the three northern Rocky Mountains recovery areas. We selected six variables that previous literature suggested were important in habitat selection by Wolves (Matteson 1992; Mladenoff et al. 1995; Oakleaf 2002) and that could be generated in ArcView from existing data layers (Table 2).

Direct solar radiation was estimated with SOLAR-FLUX (Rich et al. 1995; running under ARC/INFO with Digital Elevation Models). SOLARFLUX models incoming solar radiation based on slope, aspect, solar azimuth and zenith, time of year, topographic features, elevation, and atmospheric conditions. We used 15 April in this model as an average date for parturition in the northern Rocky Mountains (C. Mack, personal communication). Because Wolf home ranges and dens in the northern Rocky Mountains have been found primarily in coniferous forests (Matteson 1992; Oakleaf 2002), a coniferous forest GIS layer was derived from National Land Cover Data. This data layer was developed from 30 m resolution as a percentage of forested cells within 100 m of den and contrast site. Elevation and slope were derived from National Elevation Data (NED). Road and water data were derived from U.S. Geological Survey (2002) Digital Line Graphs (DLG) and Topologically Integrated Geographic Encoding and Referencing system [TIGER] (U.S. Census Bureau 2002). Distances from dens to water and roads were calculated with distance functions in ArcView. We did not distinguish among four TIGER road classes (primary highways with limited access; primary roads without limited access; secondary and connecting roads; and local, neighborhood, and rural roads).

We used Mahalanobis Distance (Krzanowski 1988; Podrutzny et al. 2002; Farber and Kadmon 2003) to

TABLE 1. Descriptions, units, and sampling methods for habitat variables measured in the field at Wolf dens and paired random locations in the northern Rocky Mountains, USA and Alberta, Canada, 2003. Field-measured habitat characteristics (SE) associated with Wolf dens ($n = 22$) vs. contrasts ($n = 22$) for Wolf den site analysis. The *site* is a single 20x20m plot, and the *area* is the average of 5 such plots—the center plot plus plots located 50 m away in the cardinal directions). Variables differing significantly ($\alpha = 0.1$, Wilcoxon's signed ranks test; bold font) were considered for entrance into the logistic regression model.

Variable	Units	Description and methods	Site			Area		
			Den	Contrast	P	Den	Contrast	P
Elevation	m	Measured with GPS unit.	1672 (397)	1756 (323)	0.25	1672 (397)	1756 (323)	0.25
Slope of site	degrees	Determined using a clinometer. Averaged slope along the fall line 10 m upslope and downslope.	15 (9)	13 (8)	0.27	15 (9.5)	14.5 (9)	0.69
Index of tree diameter	inches	Measured diameter of each tree >2" DBH touching the transect ^a tape.	7.4 (8.5)	5.8 (4.2)	0.17	5.8 (6.4)	7.1 (6.1)	0.16
Canopy closure	%	Estimated at plot center using a spherical densiometer (Lemon 1957).	88 (22)	59 (36)	0.009	65 (34)	60 (36)	0.19
Hiding cover	%	Average percent obscured of a 2-m high cover pole observed 15 m away in each cardinal direction (Griffith and Youtie 1988).	72 (24)	47 (30)	0.007	57 (23)	49 (29)	0.026
Presence of water within 100 m	categorical (0/1)	Presence or absence of standing water, permanent or ephemeral streams of any size within 100 m of den.	15	7	0.017	15	7	0.017
Herbaceous ground cover	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above an herbaceous plant.	40 (15)	30 (17)	0.020	42 (18)	31 (18)	<0.0005
Leaf/needle litter	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above leaf/needle litter.	28 (13)	29 (18)	0.88	26 (15)	30 (19)	0.096
Shrub cover	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above a plant 20–200 cm tall.	12 (8)	18 (16)	0.14	15 (12)	16 (16)	0.80
Small woody debris	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above woody debris 5–15 cm in diameter.	5 (4)	2 (2)	0.046	4 (4)	3 (4)	0.56
Large woody debris	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above Woody debris >15 cm in diameter.	4 (6)	4 (6)	0.61	3 (4)	3 (4)	0.47
Soil cover	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above bare soil, including rocky <2.5 cm in diameter.	6 (4)	8 (10)	0.98	5 (6)	7 (10)	0.025
Rock cover	%	Fraction of meter marks ($n=63$) on the transect ^b that lay above rocky material >2.5 cm in diameter.	1 (2)	5 (15)	0.066	2 (7)	5 (16)	0.038
Tree cover	%	Fraction of meter marks ($n=63$) on the transect ^b that touched a tree >200 cm tall or the tree root system.	5 (5)	5 (6)	0.36	4 (5)	5 (7)	0.82

^a χ^2 test

^b Three 20-m transects were placed 10m apart, perpendicular to the aspect of the hill.

TABLE 2. GIS variables used in habitat selection for Wolf den site analysis in the Northern Rocky Mountains, USA, 2003. Mean (SE) of remotely-sensed variables measured at Wolf dens ($n = 35$) and contrast sites ($n = 35$).

Variable	Units	Resolution	Source	Dens		Contrasts		P
Distance to Roads	m	1:100 000	USGS DLG (1983) ^{a,c} TIGER ^b	2654	(3432)	3039	(4855)	0.86
Distance to Water	m	1:100 000	USGS DLG (1983) ^{a,b} TIGER ^c	412	(311)	533	(483)	0.41
Coniferous Forest	0/1	30 m	GAP (USGS 2002)	59	(44)	54	(44)	0.48
Elevation	m	30 m	USGS NED	1916	(404)	2011	(389)	0.1
Slope	°	30 m	USGS NED	19	(16)	20	(16)	0.54
Solar Radiation	W/m ²	30 m	Based on NED, Calculated with SolarFlux ^d	5822696	(1351423)	5642444	(1500068)	0.54

^a Idaho USGS: United States Geological Survey

^b Montana DLG: Digital Line Graphs

^c Yellowstone National Park NED: National Elevation Data

^d 15April, 0900-1500

model potential denning habitat across the study area. This measure of dissimilarity is the squared distance between the vector of habitat variables measured at any location in the landscape, and the mean vector for all den sites ($n = 35$). We used elevation, slope, solar radiation, and coniferous forest cover at 30 meter resolution as variables based on previous studies that suggested their importance (Mech 1970; Matteson 1992; Unger 1999). Distance to roads and water were not used because resolution of the data set was too coarse. Mahalanobis distances were calculated using an ArcView extension (Jenness 2003*).

Because Mahalanobis distances have no upper limit, the values were converted to Chi-square P -values (Clark et al. 1993). P -values closer to 0 reflect a high Mahalanobis distance and high dissimilarity to observed den habitat, where P -values closer to 1 are similar to den sites. Each P -value defines a habitat model. We evaluated models by calculating the percentage of Wolf dens and percentage of the landscape that exceeded various threshold P -values. We considered a model useful if it encompassed >85% of dens within suitable habitat that comprised < 25% of the landscape.

Location of dens within home range boundaries

To assess if Wolves located den sites within core use areas, we examined the location of each den relative to the home range boundaries. Fixed kernel home range estimators (Powell et al. 1997; Seaman et al. 1999) were generated using radio telemetry data, ArcView 3.2 (Environmental Systems Research Institute 1992) and the ArcView Animal Movement Extension (Hooge et al. 1999). We constructed 95% polygons to represent Wolf home ranges exclusive of outliers and 50% polygons to represent a core use area within home ranges. We used telemetry locations taken from 1 August of the previous year to 31 July of the denning year to calculate home ranges for this analysis. Although Seaman et al. (1999) suggested a minimum of 30 telemetry locations to generate a fixed kernel home range, three packs with 20-28 locations were included. Because telemetry flights are usually increased during the denning season (April-June), to determine

den locations, a sampling bias existed. To reduce this bias, if >25% (¼ of the year) of locations for a home range were obtained during the denning period, we randomly removed locations from the denning period until that period included only 25% of all annual locations. Because not all packs were collared and some collared packs were not monitored for several months during the year, only eight Idaho dens and four Montana dens could be evaluated.

Results

Den site characteristics

Twenty-three of 25 dens were hillside excavations with an average slope of 15 ± 9 degrees (Table 1). Twelve of the hillside excavations were categorized as "open," since they were not directly under a tree; ten were under trees, and one was under a downed tree. Most dens were clean and dry with hair in the soil and hanging from the roof. Average height and width of entrances were 43.9 ± 18 cm and 48.3 ± 15 cm, respectively. Average depth of the excavations was 282 ± 139.9 cm. Most den holes descended with 17-42 degree slope for approximately one meter before leveling or slightly climbing to an enlarged birthing/nursing chamber. Interior measurements averaged 50.5 ± 25.9 cm for height and 90.3 ± 38.3 cm for width. Land ownership was: U.S. Forest Service (68%), National Park Service (12%), Bureau of Land Management (8%), private (8%) and state (4%).

The most common tree species at den sites was Douglas-fir (*Pseudotsuga menziesii*), followed in order of occurrence by Engelmann Spruce (*Picea engelmannii*), Lodgepole Pine (*Pinus contorta*), Trembling Aspen (*Populus tremuloides*), Grand Fir (*Abies grandis*), Western Larch (*Larix occidentalis*), and Limber Pine (*Pinus flexilis*). Major shrub species occurring at den sites, from most to least common included: snowberry (*Symphoricarpos albus* and *S. oreophilus*), rose (*Rosa* sp.), Grouseberry (*Vaccinium scoparium*), Creeping Oregon-grape (*Berberis repens*), Mountain Huckleberry (*Vaccinium globulare*), Saskatoon (*Amelanchier alnifolia*), Common Juniper (*Juniperus communis*),

TABLE 3. Logistic regression model predicting Wolf den sites (20×20m plot centered on den) vs. contrast sites in the Northern Rocky Mountains, USA, 2003.

Variable	Coefficient	SE	Coefficient/SE	P-value	R
Water within 100m	1.39	0.85	1.64	0.099	0.11
Canopy Cover	0.042	0.018	2.33	0.018	0.24
Herbaceous Cover	0.078	0.035	2.23	0.024	0.23
Small Woody Debris	0.21	0.13	1.62	0.11	0.094
Constant	-7.12	2.34	-3.04	0.002	

TABLE 4. Logistic regression model predicting Wolf den areas (the den site plus 4 similar satellite plots 50m from den) vs. contrast areas in the Northern Rocky Mountains, USA, 2003.

Variable	Coefficient	SE	Coefficient/SE	P-value	R
Hiding Cover	0.014	0.007	2.03	0.049	0.08
Herbaceous Cover	0.04	0.01	4.17	<0.005	0.22
Leaf/needle Cover	0.025	0.011	2.23	0.0666	0.23
Water within 100 m	1.31	0.33	3.97	0.0001	0.21
Constant	-2.73	0.6	-4.55	0	

Birch-leaved Spiraea (*Spiraea betulifolia*) and Big Sagebrush (*Artemisia tridentata*).

Compared to contrast sites, den sites had greater canopy closure, hiding cover, herbaceous ground cover, woody debris, but less rock (Table 1). Average canopy closure was $88 \pm 22\%$. Average hiding cover was $82 \pm 21\%$ from 0-1 m above ground level, and $61 \pm 26\%$ from 1-2 m above ground level for a combined total of $72 \pm 24\%$. Den areas had greater hiding cover, more herbaceous ground cover, but less leaf and pine litter than contrast areas (Table 1).

Fine-scale habitat selection using field-collected data

Six of the 14 habitat variables differed ($P < 0.10$) between den and contrast sites (single 20×20 m plots), and were candidates for the logistic regression model (Table 1). Canopy Cover and Hiding Cover were highly correlated ($|r| = 0.53$), so Hiding Cover was removed because it was less significant. The model (Table 3) included Water within 100 m, Canopy Cover, Herbaceous Cover, and Small Woody Debris; and classified 86% (19 of 22) of the contrast sites and 82% (18 of 22) of the den sites for a combined accuracy of 84%.

Six variables differed between den and contrast areas (clusters of five plots): Water within 100 m, Hiding Cover, Herbaceous Cover, Leaf/needle Cover, Soil Cover and Rock Cover, none of which exhibited multicollinearity. The model (Table 4) included Hiding Cover, Herbaceous Cover, Leaf/needle Cover, and Water within 100 m and classified 74% (16 of 22) of the contrast areas and 70% (15 of 22) of the den areas for a combined accuracy of 71%.

Coarse-scale habitat selection using remotely-sensed data and developing a predictive model of suitable den site habitat

None of the six variables derived from remotely-sensed data differed significantly between den and

contrast sites (Table 2). Habitat characteristics varied considerably among Wolf dens such that 70% of the 35 dens were dissimilar (Mahalanobis $P \leq 0.40$ – Figure 1) to the mean habitat vector. But most of the Northern Rocky Mountains landscape was even more dissimilar to the mean habitat vector, with >80% of the study area having Mahalanobis $P < 0.10$. The 12% of the landscape that most resembled mean den habitat encompassed 89% of sampled Wolf dens, and the 18% of the landscape most similar to the mean encompassed 91% of the dens (Figure 1).

Location of dens within home range boundaries

Eleven of 12 dens were located in the 50% core use area. The kernel estimator identified two or three discontinuous core areas for five territories. In these cases, three of five dens were located in the largest of the 50% core areas. The 50% kernel size ($\bar{x} = 148 \pm 197$ km²) was approximately 18% of the 95% kernel size ($\bar{x} = 761 \pm 653$ km²). MCP home range size averaged 585.3 ± 453.2 km². Only 45% of the locations within the 50% kernel were from the denning period (April-June).

Discussion

Den site selection appears strongest within 15 m of the den entrance but was also apparent (but less pronounced) within a 50-m radius of the den. We found dense cover (> 70% obscuration) near dens, and dens were often difficult to find and could rarely be seen from >20 meters. Previous studies in Montana (Matteson 1992), and Wisconsin and Minnesota (Unger 1999) did not find a significant cover difference between den and contrast locations. Matteson (1992) measured cover at 30.5 and 61 m, with cover values of $66.1 \pm 27.3\%$ and $91 \pm 17.3\%$, respectively. In our opinion, Matteson measured cover at inappropriately long distances, which resulted in high horizontal cover

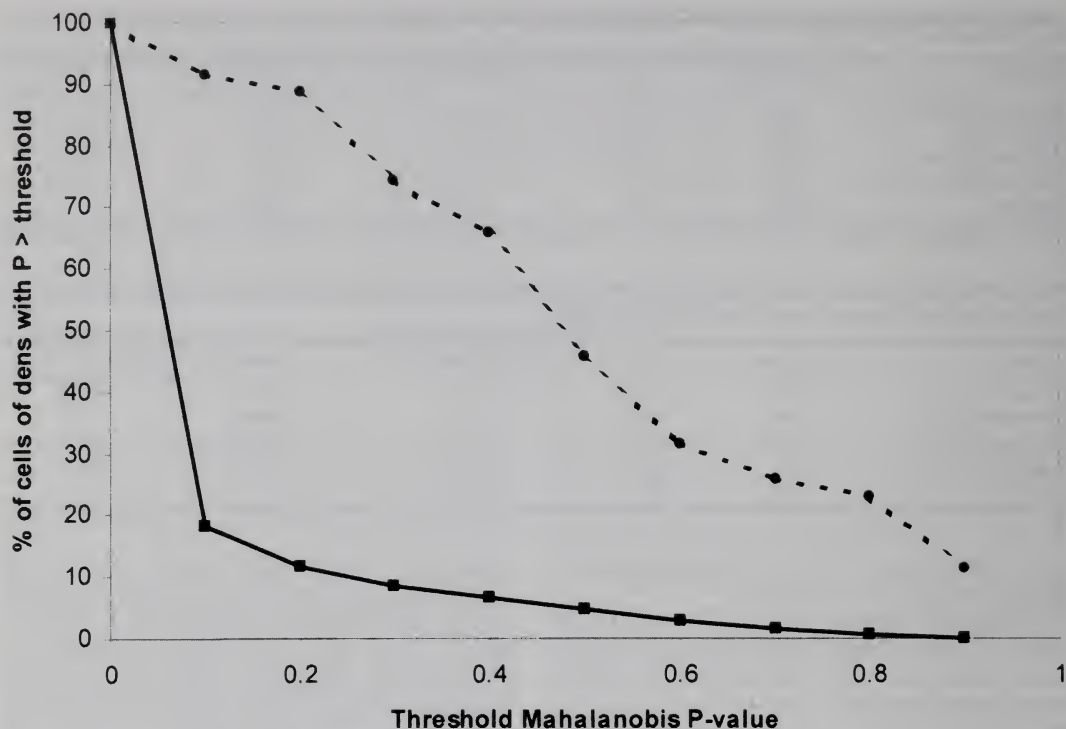


FIGURE 1. Percent of dens (dashed line) or cells (solid line) with Mahalanobis- P greater than or equal to threshold value for Wolf den site analysis in the northern Rocky Mountains, USA, 2003. Higher values along the x-axis indicate greater similarity to the mean vector of habitat measurements at Wolf dens.

values and reduced power to detect differences. Unger (1999) found average hiding cover at dens to be $70 \pm 24\%$ at 16 m, which is comparable to our results ($72 \pm 24\%$).

Canopy cover at den sites was considered unimportant by Matteson (1992) and Unger (1999). Both reported lower mean canopy cover values ($43 \pm 9\%$: Unger 1999; $19 \pm 21\%$: Matteson 1992) than the $88 \pm 22\%$ we observed. These differences might be explained by the different collection methods. Matteson visually estimated canopy cover, whereas Unger used a point-intercept method. Nuttle (1997) suggested that point-intercept methods may not reflect an animal's perception of canopy cover.

Unger (1999) found steeper slopes at dens versus contrast sites. Although we did not identify slope as a selected den site attribute, our average slope of 15 degrees was similar to Unger's 14 degrees. Matteson (1992) found average slopes of 9 ± 11 degrees. Stephenson (1974*) found a much steeper average slope of 33 degrees in the Brooks Range of Alaska. Using elevation and slope measured in a GIS model, Oakleaf (2002) found core areas of pack home ranges in the northern Rocky Mountains at lower elevations with gentler slopes. Although we found that most dens were located within home range core areas, we found no

significant correlation between den sites and elevation or slope.

Variables displaying significance at den site and den areas included Hiding Cover, Herbaceous Cover, and Rock Cover. Increased bare soil was significantly different at den areas but not at den sites. Denser canopy cover and small woody debris were significant at the site level, suggesting that Wolves respond to these two habitat variables immediately surrounding the den entrance. Denser canopy cover at the den entrance could suggest that Wolves select areas with more vertical protection, or this could be an artifact of selecting den sites near tree roots for increased structural integrity. Although small woody material may provide little structural defense from ground predators, it may provide visual obscurity.

Road and water GIS layers at 1:100 000 resolution were inaccurate when compared to field observations. In the field, we found most dens to be within 100 m of water, although GIS data revealed only three water sources within that distance. GIS layers depicted roads within 30 m of several dens where we found no roads in the field. These inaccuracies may have contributed to the lack of significant differences in variables derived from remotely-sensed data (Table 2). Hawbaker and Radeloff (2004) found that up to 50% of the roads in

the landscape may be missing in digital road data. Their findings and our identification of "ghost" roads suggest that digital road data should be used with caution or field checked.

Eleven of 12 dens sampled were located within core areas (50% fixed kernel). Unger (1999) found that dens occurred more often in the central part of the MCP [minimum convex polygon], but Ciucci and Mech (1992) found Wolf dens located randomly throughout the MCP home ranges. Unger (1999) and Ciucci and Mech (1992) used different geometric methods to characterize den location as either being centrally or peripherally located in the MCP home range. Because the 50% fixed kernel estimator reflects the intensity of use in the home range, we believe it is a better predictor of denning areas. In our study only 45% of the locations within the 50% kernel were from the denning period (April-June). This suggests that Wolves use the denning area throughout the year.

Although Wolf den locations varied considerably with respect to elevation, slope, solar radiation, and coniferous forest cover, we identified several useful Mahalanobis distance models using these GIS data layers. Mahalanobis models with threshold P values of 0.10 to 0.20 are useful to managers, who can expect that about 90% of dens will occur within < 20% of the landscape. By combining Mahalanobis modeling with fixed kernel home ranges and core use areas, potential denning habitat can be predicted.

Conservation implications

Although some GIS-derived data layers appeared to be accurate (e.g., elevation, slope, aspect), other data layers (e.g., roads and water) were highly inaccurate compared with site-specific data measured in the field. As GIS use becomes more prevalent, managers should be aware of some of its potential limitations.

Mahalanobis models can help managers identify suitable den habitat. Of the models we developed, any with $P < 0.20$ would be useful to managers. Managers can use these models to evaluate the amount of potential denning habitat in Wolf-occupied areas or proposed reintroduction sites. Mahalanobis distances can be calculated at landscape, pack home range, or core use area scales.

When making land use decisions, managers are often provided with 100% MCPs for Wolf territories. Because territories in the Northern Rocky Mountains are large, averaging over 500 km², it may be difficult to meet management objectives. Smaller core areas based on 50% kernel estimator may be a better delineation for land use decisions because they show areas of more intense use. More than 90% of the dens we examined were located within the core use area of the pack, and these areas are being used throughout the year. Localized closures (e.g., one-kilometer diameter) during the denning period will decrease likelihood of premature abandonment of the den.

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Distribution and History of Naturalized Common Pear, *Pyrus communis*, in Ontario

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Considered rare or entirely overlooked until 1998, *Pyrus communis* is currently widespread and locally abundant as an escape from cultivation in southern Ontario. It was first noticed growing wild in Elgin County in 1949 and up until 1965 it was known as a wild plant only in the eastern Lake Erie region. It was first reported in the eastern Lake Ontario region in 1969 and is now widespread and locally abundant there. It now occurs north to the Georgian Bay region, and southwest to Essex County. Since it has had a very effective and rapid dispersal system for centuries as a result of cultivation and discarded cores, the apparently recent spread may be a consequence of climate warming extending the area within which it can grow wild, otherwise it would have escaped much earlier. It occurs in old fields and along fences within agricultural landscapes, but has been recorded in native woodland, prairie and alvar habitats. It dominates abandoned fields and pasture in some areas and may also increase in certain natural habitats and compete with native species. It is, however, less aggressive than some other alien woody plants and provides abundant food in the form of pollen, nectar and fruit during the early stages of old field succession. Spread is believed to be mostly by humans, but Raccoons, deer, and other small mammals may be important in local dispersal.

Key Words: Common Pear, *Pyrus communis*, invasive alien, distribution, naturalized, wild, woody plants, Ontario.

Since the Common Pear (*Pyrus communis* L.) can grow to a very old age (Catling and Small 2007), planted specimens may last for a long time and may even resprout from old bases. Consequently, planted specimens may appear as escapes in secondary forest and in old fields and around home sites. The status of large old trees as persisting or escaped is thus difficult to determine. Dodge's (1914) report of "several large trees, apparent escapes, along the north shore of Lake Erie" may well have been planted. However, in several parts of Ontario, young pear trees of all ages are spreading through old fields and along fences and even into openings in native woodlands. It is well known that apples spread on their own from cultivated trees or discarded cores, but it is less widely known that pears have done the same thing. In fact some of the basic references to wild plants in Ontario, *Trees in Canada* (Farrar 1995) for example, fail to mention wild pears. Boivin (1966) indicated naturalized apples across Canada but no naturalized pears. Soper (1949) included Common Pear in his southern Ontario checklist and so did Morton and Venn (1990) in their later checklist, but neither indicated status. Scoggan (1978) noted escape only in Niagara and Welland counties (now Regional Municipality of Niagara) in the eastern Lake Erie region. A number of regional floristic inventories include reference to pears which are presumably wild because these inventories feature plants growing without cultivation. However, the status of wild pears in the province overall was not clear and the impression given is that wild pears are scarce. However, the Ontario plant list (Newmaster et al. 1998) has the status in the

province listed as "ORNAMENTAL SE4", meaning escaped from cultivation and common with at least 100 occurrences. Based on recent personal observations this seems to be correct suggesting that the status of Common Pear in Ontario as a wild plant may have changed appreciably over the past few decades. An interest in wild pear germplasm as well as the need for a better understanding of the status and distribution of invasive plant species required a review of wild pears in Ontario.

Methods

Specimens were examined from various herbaria with good Ontario representation, including CAN, DAO, HAM, LKHD, OAC, QK, TRT, TRTE, UWO and WAT [(acronyms from Index Herbariorum (Holmgren and Holmgren 1998)]. Identifications were checked and label data were recorded and entered into a database. Plants indicated clearly to be "escaped from cultivation" or "not cultivated" were mapped by year to explore distributional history.

Results and Discussion

Variation and identification

At a distance, flowering pears are whiter and have more erect branches (Figure 1) than apples, which are often pinkish and spreading. The flower clusters of pears have a central axis (Figure 1) whereas those of apples have all of the flower pedicels arising at the same point. Pears also tend to have more shiny and leathery leaves. Although all of the wild pears so far examined in Ontario are referable to *P. communis*,



FIGURE 1. Common Pear (*Pyrus communis*) escaped from cultivation west of Trenton (at 44.18440°N, 76.7669°W), Ontario. A young tree with upright branches is shown on the left. On the right is a portion of an inflorescence showing the elongate main axis of the flower cluster. Photos by P. M. Catling, 13 May 2006.

some of the populations are very variable. On the northeast side of Kingston, where thousands of trees have invaded abandoned pasture, the individual trees have flowers with long reflexed sepals or short spreading sepals, some are thorny while others are not, some have leaves that retain pubescence on both surfaces (but particularly below) until well after flowering whereas others lose all pubescence before fully expanding. This variation is not surprising, given the likely diverse parentage of the trees producing the seeds. Some cultivars are believed to be partly of hybrid origin, including *P. nivalis* Jacq. and other related species (Bell 1990). Callery Pear (*Pyrus calleryana* Decaisne) is becoming increasingly popular as an ornamental in Ontario. It has not yet been reported as an escape here, although it has become a troublesome escape further south (Nesom 2000; Vincent 2005). It is sold in Ontario nurseries north at least to Kingston. The likelihood of its escape in Ontario is suggested by the fact that it occurs as an escape in zone 6 in Michigan. This zone includes parts of Essex County in extreme southwestern Ontario (Vincent 2005). *Pyrus calleryana* has flowers with 2 – 3 styles instead of 5 as in *P. communis*. The fruit of *P. calleryana* is about 1 cm in diameter, globose, and blackish-brown with pale dots. The fruit of *P. communis* is 3 – 10 cm long, obovoid or pyriform, and yellowish without prominent pale dots.

Distribution and History

Although *P. communis* was first cultivated by the Jesuits along the Detroit River in 1705 (Catling and Small 2007), the earliest record of *P. communis* growing wild in Ontario is a collection in 1949 from Yarmouth Township in Elgin County on the label of which collector L. E. James wrote: "thickets and roads – escaped from cultivation". This is followed by several collections in 1955 from the wild areas of the Royal Botanical Garden in Hamilton by A. Tamsalu. It was collected elsewhere in the Carolinian region over the next decade, but was still known as a wild plant only from the area of eastern Lake Erie until 1968 (Figure 2). Nineteen collections were made in this area of extreme southwestern Ontario prior to the first record from the eastern end of Lake Ontario in 1969, at which time it was considered to be a rare escape (Beschel et al. 1970), but a quarter century later it was still listed as rare in that region (Crowder, et al. 1996). However, our field work in the region, 10 years later, revealed at least 50 localities (defined as 1 km apart), many with hundreds of trees of all ages and some with more than a thousand trees in a square km. Since Ontario field botanists of the mid-twentieth century were comprehensive in their collection of, and reference to, wild-growing plants, the preceding indications are considered reliable. For example, where Beschel and his team

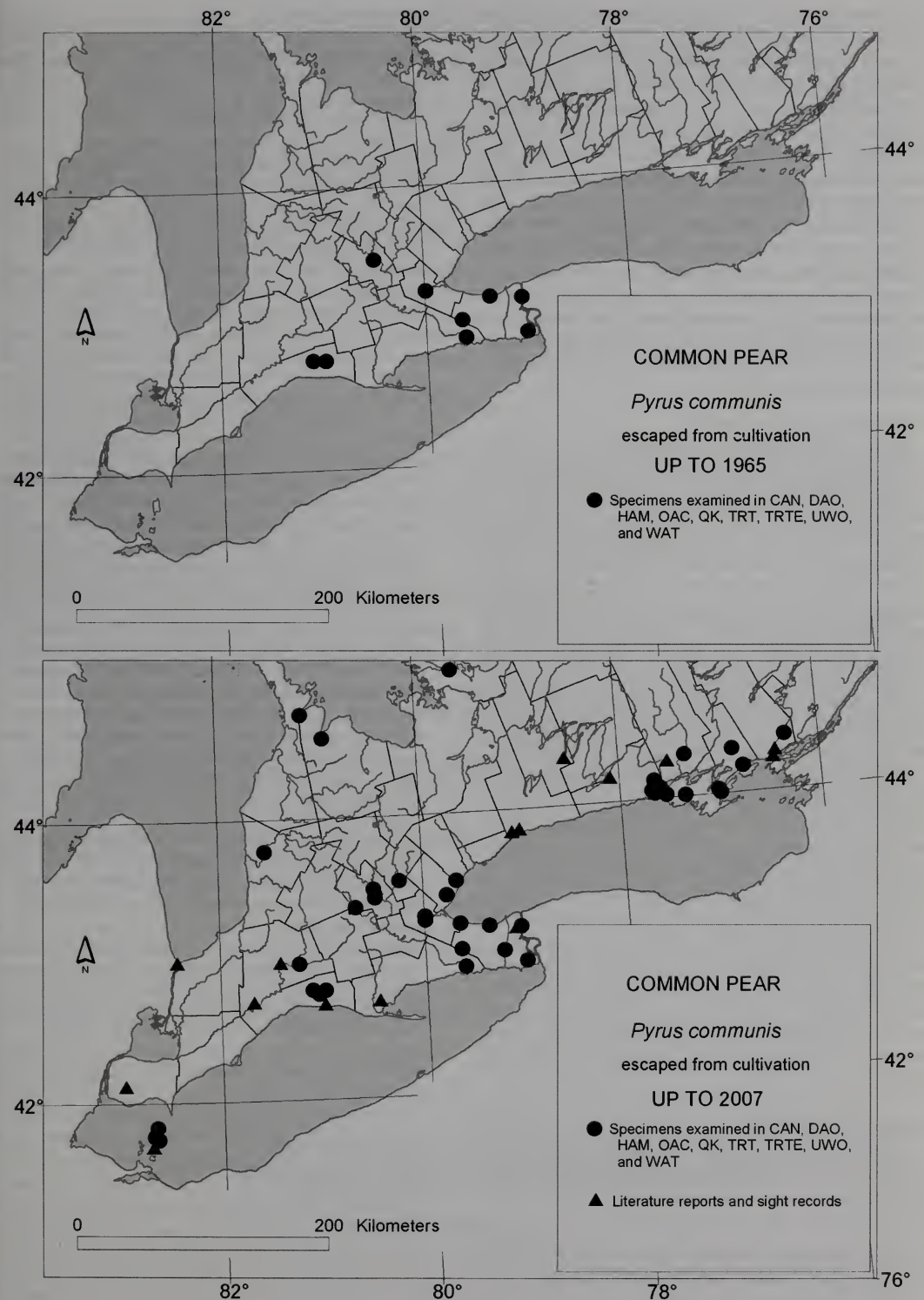


FIGURE 2. Distribution of wild (non-planted) *Pyrus communis* in Ontario. The dots represent specimens examined in herbarium collections (see methods) whereas the circles indicate literature reports and sight records of the authors and M. J. Oldham. Above, distribution up to 1965 confined to the northeastern Lake Erie region. Below, distribution up to 2007.

of experts suggest that it was a "rare escape" in the Kingston region in 1970, this is entirely to be trusted. Common Pear was first recorded as a wild plant in the Georgian Bay region from Wiarton and Muskoka in 1974 and 1975, respectively. Its apparently later establishment (after 1965) in more northern areas such as the eastern Lake Ontario region and Georgian Bay may be a consequence of a warming climate recently extending the area within which it can grow wild. This is based on the idea that since it has had a very effective and rapid dispersal system for centuries as a result of introduction, cultivation and discarded cores, it would likely have escaped over a broad region of southern Ontario at a much earlier date if the climate could have been tolerated. Its distribution as currently known includes much of southern Ontario south of the Canadian Shield region (Figure 2).

Ecology and potential impacts

Common Pear grows well in drought-prone, shallow soils over limestone near Trenton and in Prince Edward County, suggesting substantial drought tolerance. It also occurs in sand, loam and clay soils of neutral to alkaline reaction, but is more often found on drier sites (Catling, personal observation). In most cases, it occurs in old fields and along fences within agricultural landscapes, but has been recorded in native woodland, prairie and alvar habitats. It dominates abandoned fields and pastures in some areas and may also increase in certain natural habitats and competes with native species, but is not considered to be a major threat to native biodiversity at this time. It is less aggressive than some other alien woody plants (Catling 1997; Catling and Mitrow 2005) and provides abundant food in the form of pollen, nectar and fruit during the early stages of old field succession. It is presumably spread mostly by humans as a result of cores discarded by people and plants transported over long distances for cultivation. Dispersal of fruits and seeds by Racoons, *Procyon lotor*, White-tailed Deer, *Odocoileus virginianus*, and possibly smaller mammals may be locally important. It is also spread by the nursery trade. These methods of spread can be extremely rapid and its occurrence in Ontario will probably be determined largely by climatic tolerance and substrate rather than factors relating to rate of spread as in many other invasive species.

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Annual vs. Multiple-Year Home Range Sizes of Individual Blanding's Turtles, *Emydoidea blandingii*, in Central Wisconsin

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Schuler, Matthew, and Richard P. Thiel. 2008. Annual vs. multiple-year home range sizes of individual Blanding's Turtles, *Emydoidea blandingii*, in central Wisconsin. *Canadian Field-Naturalist*. 122(1): 61-64.

Most studies of home ranges occur over short time periods and may not represent the spacial requirements of long-lived organisms such as turtles. Home ranges of 18 individual Blanding's Turtles (*Emydoidea blandingii*) were measured using minimum convex polygons. Annual space use was compared to multi-year space use by individual turtles. We found a significant difference between annual home range size (25.5 hectares) and multi-year (two to six years) home range size (65.7 hectares; $n = 18$, $P = 0.016$). Caution should be employed when making management decisions based on short-term studies of long lived species.

Key Words: Blanding's Turtle, *Emydoidea blandingii*, life range, home range, Wisconsin.

Annual home range is the total area used by an organism in a given year for daily life activities such as foraging, mating, hibernating, and resting (Burt 1943). The short duration of typical wildlife studies (one to three years) adequately captures the spacing mechanisms used by most organisms because of their relatively short life-spans. The concept of a life-long home range for long-lived species is something that has not been seriously studied because, until recently, most wildlife research has not focused on animals with prolonged life-spans such as turtles (Brecke and Moriarty 1989; Grgurovic and Sievert 2005).

Blanding's Turtles are a long-lived species. A record exists of one in Minnesota reaching 77 years of age (Brecke and Moriarty 1989; Pappas et al. 2000). Reported home range sizes of Blanding's Turtles vary from 0.6 hectares (Ross and Anderson 1990) to 63.0 hectares (Piepgras and Lang 2000). These home range studies were of one or two years in duration. Grgurovic and Sievert (2005) noted that short-term home range data for Blanding's Turtles may be inadequate: "In our 2-year study of Blanding's turtle home ranges we found a low amount of home range overlap for the same individuals followed..., indicating that our calculations greatly underestimate lifetime home ranges for single animals."

In 1994 we began radio-tagging Blanding's Turtles in Sandhill Wildlife Area, managed by the Wisconsin Department of Natural Resources. Our intent was to teach secondary-level students the importance of wetlands and how biological data on wildlife, such as spacial needs, are acquired through field studies. For convenience, we attempted to re-radio the same Blanding's Turtles each spring because familiarity with individual turtle home ranges facilitated location and recovery when escorting school groups in area marshes. This provided a unique opportunity to compare single-year

and multi-year home ranges of radio-tagged Blanding's Turtles monitored from one to six consecutive foraging seasons to test whether differences really existed, as suggested by Grgurovic and Sievert (2005). We report the results in this paper.

Study Area

Sandhill Wildlife Area is a 3884 hectare research facility located in Wood County, Wisconsin (44°17'N, 90°10'W). The property is surrounded by a 29 km long, 3 m high, deer-tight fence. During the Wisconsinan glacial event, Sandhill was covered by sandy lake bottom sediments. Post-glacial soils produced a mixture of habitats, such as sphagnum bogs, sedge meadows, willow (*Salix* spp.) swamps and upland oak (*Quercus* spp.), Jack Pine (*Pinus banksiana*) and aspen (*Populus* spp.) forests (Kubisiak et al. 2001).

In the late 1800s and early 1900s, ditches and dikes were constructed to drain this region's extensive wetland complexes for agricultural purposes. Between the 1930s and 1950s large acreages were converted to public land ownership, and many of the low-lying areas were re-flooded to create waterfowl habitat. Blanding's Turtles managed to persist despite these disturbances to their preferred habitats (Piepgras and Lang 2000; Bury and Germano 2003; Grgurovic and Sievert 2005).

Monthly temperatures for the region in the past 30 years ranged from a mean low of -9.8 degrees Celsius in January to a mean high of 20.7 degrees Celsius in July. Average annual precipitation was approximately 81 cm, and annual snowfall averaged 105 cm (Midwest Regional Climate Center 2000-2005*).

Methods

Blanding's Turtles were captured opportunistically by hand April through November annually since 1991, and with hoop traps in June through August 1997, 1998,

and 2002. Turtles were weighed, measured, sexed and aged by counting plastral scute growth rings (Sexton 1959; Congdon et al. 1993). Each turtle was given a unique number by notching a series of marginal scutes for future identification (Cagle 1939). Radio transmitters (Advanced Telemetry Systems, Model R1930, average weight 28 g) were glued on the anterior portion of the carapace of two to four turtles annually beginning in 1994. These turtles were held overnight and released the next morning.

Radio-tagged turtles were located by following transmitter signals to the turtle, and occasionally through triangulation. Locations were plotted on habitat maps drawn from aerial photographs. Single active season locations (April through September) were plotted and used to estimate annual home range sizes using the minimum convex polygon method (Mohr 1947). We used the same method to determine multiple-year home range size (Figure 1). We defined multiple-year home range as the aggregate of greater than or equal to two foraging seasons (April through September) for a single turtle.

To compare male and female single-year home ranges, we used a paired *t*-test. We used a paired *z*-test for comparing independent means to analyze the difference between the mean yearly home range size of turtles radioed for a single year and the mean yearly home range size of turtles radioed for multiple years. A paired *t*-test was used to examine the difference between the mean yearly home range size and the mean multi-year range size of nine turtles. We performed a regression analysis comparing the amount of habitat aggregated over a number of years. This was used to show an increase in habitat used per year in an individual turtle. For all analyses, significance was accepted at $P < 0.05$. Data were analyzed using SPSS (SPSS Inc., Chicago, Illinois).

Results

Nine radio-tagged Blanding's Turtles (3 males: 6 females) were monitored for a single year, and nine different turtles (6 males: 3 females) were radio-tagged for at least two years.

Mean annual home range size for 9 males (26.1 hectares) and 9 females (20.7 hectares) radioed for at least one active season did not differ significantly ($n = 18$, $P = 0.5$, $df = 17$). Additionally, mean yearly home ranges of turtles radioed for a single year did not differ significantly from mean yearly home range sizes of individuals that were radioed for multiple years ($n = 18$, $P = 0.55$, $df = 17$, $z = 1.96$). This indicates that individual turtles are utilizing essentially the same sized habitat each summer foraging season, and confirms that no differences existed between turtles in our two sub-samples (annual vs. multi-year range).

Turtles monitored over multiple years showed a significant difference between annual home range size (25.5 hectares) and multi-year range size (65.7 hectares) ($n = 18$, $P = 0.016$, $df = 17$). Figure 2 shows the

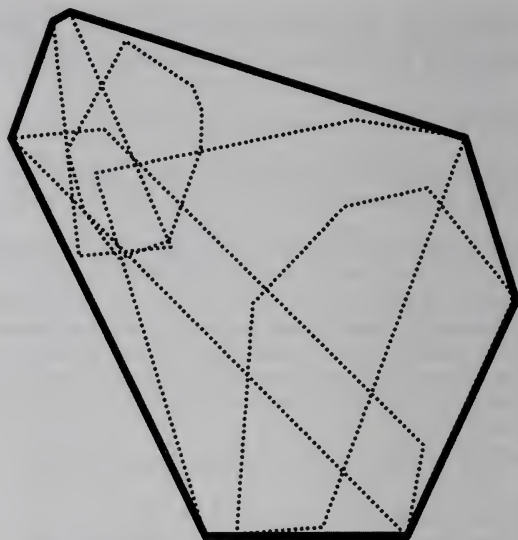


FIGURE 1. Single-year (dashed lines) vs. multiple-year (solid line) home range of Blanding's Turtle 058 male.

significant increase in space used by turtles monitored over multiple years ($n = 9$, $r^2 = 0.49$, $P < 0.001$).

Discussion

Blanding's Turtles are experiencing population declines and are presenting management concerns for resource agencies (Grgurovic and Sievert 2005; Kingsbury 2007*). As of 2006, the species was listed as extirpated in three state/provincial jurisdictions; endangered in four; threatened in 10; a species of concern in four; and unprotected in one (Table 1). Destruction of their wetland habitats is a primary cause of such declines, exacerbated by such aspects of their life history as delayed sexual maturity, low recruitment rates, intolerance to accelerated adult mortality rates concomitant to disproportionate rates of gravid female vehicle-caused mortality, and relatively large home range sizes (Congdon and van Loben Sels 1993; Joyal et al. 2001; Steen and Gibbs 2004; Gibbs and Steen 2005; Grgurovic and Sievert 2005). Information on the species' basic needs are vital to restoring or protecting vital habitat for Blanding's Turtles, and it is therefore crucial that data on home range size accurately reflects the species' needs.

Similar to the findings of Grgurovic and Sievert (2005), our Blanding's Turtles displayed significant differences between annual and multiple-year home range sizes. This difference indicates that over their entire life-spans, Blanding's Turtles are undoubtedly using much larger areas than would be revealed in a study of only one or two years' duration. With the exception of Grgurovic and Sievert (2005), we are unaware of any other studies that analyzed long-term differences in home range sizes of individual Blanding's Turtles. Given the long life-spans of Blanding's Turtles, man-

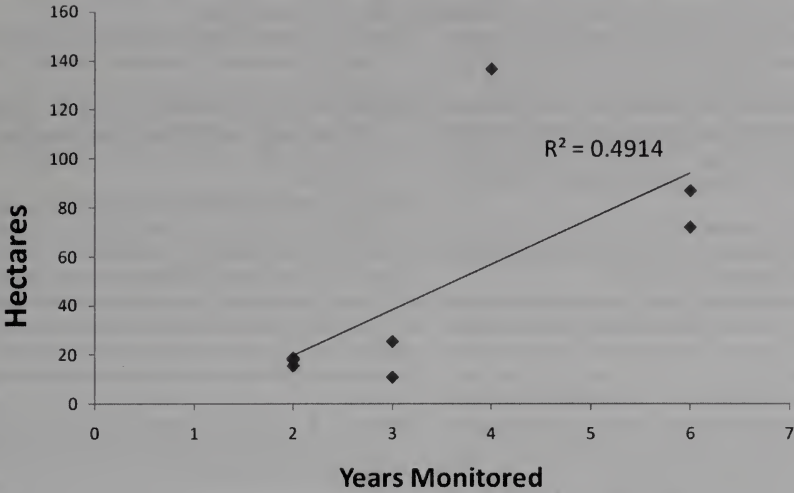


FIGURE 2. Linear relationship of expanding Blanding’s Turtle home range size as a function of years monitored.

TABLE 1. Status of Blanding’s Turtles throughout the entirety of its range, 2006.¹

State/Province	Current Status of Blanding’s Turtles				
	Endangered	Threatened	Species of Concern	Unprotected	Extirpated
Connecticut					X
Illinois		X			
Indiana	X				
Iowa		X			
Maine	X				
Massachusetts		X			
Michigan			X		
Minnesota		X			
Missouri	X				
Nebraska				X	
New Hampshire			X		
New York		X			
North Dakota	X				
Nova Scotia		X			
Ohio			X		
Ontario		X			
Pennsylvania			X		
Quebec		X			
Rhode Island					X
South Dakota		X			
Vermont					X
Wisconsin		X			
Total	4	10	4	1	3

¹Kingsbury 2007*

agers should be alert to the duration of spatial studies when using information from such studies in making landscape management decisions that may affect this and other species of long-lived turtles.

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Notes

Why do North American Red Squirrel, *Tamiasciurus hudsonicus*, Mothers Relocate Their Young? A Predation-based Hypothesis

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Kerr, Tricia, and Sébastien Descamps. 2008. Why do North American Red Squirrels, *Tamiasciurus hudsonicus*, relocate their young? A predation-based hypothesis. *Canadian Field-Naturalist* 122(1): 65-66.

Our study reports the first observations consistent with Short-Tailed Weasel predation on juvenile North American Red Squirrels in the nest. Red Squirrel mothers are known to relocate their young to another nest after a disturbance. We suggest that this behaviour might be an efficient strategy that reduces the impact of litter depredation by weasels.

Key Words: North American Red Squirrel, *Tamiasciurus hudsonicus*, Short-Tailed Weasel, *Mustela erminea*, nest predation, juvenile survival, juvenile relocation, arboreal foraging, nest defence.

North American Red Squirrels, *Tamiasciurus hudsonicus*, are known to move their juveniles from one nest to another several times during the period of rearing, especially after nest disturbance (Smith 1968; Long 1993). Although some populations of red squirrels have been intensively studied during the past two decades, this "relocating behaviour" has not received much attention and its adaptive significance remains unknown. At least two explanations can be proposed to explain its existence in an adaptive context. The first one is based on parasitism: survival and growth of juveniles or of the mother herself (Neuhaus 2003) may be enhanced if a female moves her young when the nest becomes too heavily infested by fleas, for example. The second one is based on predation: a female moves her young to decrease predation risk or predation impact on her litter. These two hypotheses are not mutually exclusive and both may play a role in the maintenance of this behaviour. We present here the first observations consistent with predation on juvenile North American Red Squirrels in the nest, which suggests that relocating behaviour by female North American Red Squirrel could enhance their breeding success by decreasing the impact of predation on their litter.

A population of North American Red Squirrels located in southwestern Yukon near Kluane Lake, Canada (61°N, 138°W), has been studied annually since 1987 (see McAdam et al. 2007 for a detailed description of the study). All female squirrels located in the study area are intensively monitored through live-trapping (Tomahawk traps, Tomahawk Live Trap Company, Tomahawk, Wisconsin), visual observations, and/or radio-telemetry from April to the end of August. Natal nests are located by tracking females near the predicted

date of parturition (determined by palpation, and monitoring nipple condition and body mass of the females) and litters are temporarily removed, immediately following parturition and again before emergence, to census offspring. Following our disturbance to nests, mothers have frequently been observed relocating young, one at a time, from nests currently in use to another nest (Kerr and Descamps, personal observations).

On 24 April 2004, we arrived at the natal nest of a recently born squirrel litter in our study grid. Before accessing the nest to census the young we saw a Short-Tailed Weasel with a ca. five to ten days old red squirrel in its mouth in front of us (~2 metres away) bounding slowly through the snow and then disappearing under the snow. After two to three minutes, the weasel reappeared without the juvenile, appeared vigilant for less than a minute, and then disappeared again under the snow. It is likely that the weasel cached the squirrel since Short-Tailed Weasels given the opportunity will kill prey and then store whatever is not immediately consumed (Simms 1979). The weasel seemed to be aware of our presence, which may explain why the weasel did not resurface again. Following this encounter we completed a survey of the litter in the current nest, which contained only one juvenile (ca. 11 days old). We then proceeded to the next natal nest; which was ~100 m away; we had earlier tracked another mother to it. There, we found a newborn red squirrel (ca. 1 day old) dead on a branch in the natal tree 1-2 m under the nest, where we also found the mother alive. The juvenile's body was flexible, a hind leg had what appeared to be puncture wounds in the thigh, and the base of its skull appeared to have been eaten out. Short-tailed Weasels kill by grasping their prey with their forelegs

and delivering a fatal bite to the base of their prey's skull (King 1983; King 1989). Weasels usually then eat the brain of a rodent first before feeding on the remainder of their prey's body (King 1989). We believe that these observations strongly support the possibility of nest predation by weasels in our population and that our first encounter was a predation rather than an opportunistic finding of a juvenile squirrel that had fallen from its nest or mother's mouth.

Short-tailed Weasels instinctively kill all live prey in sight (King 1989) and young squirrels in their natal nest would be extremely vulnerable if it was not possible for an adult to chase or lure away a weasel. Defence against a weasel has been observed at our study site, where a Red Squirrel came down from its nest and chased a Short-Tailed Weasel away from its midden (J. T. Humphries, personal communication). This may provide an understanding of the advantages for female red squirrels moving juveniles from one nest to another. Weasels preying on juvenile squirrels after finding their nest may be interrupted by a protective mother and, in accordance with what we observed, may take only one juvenile and then move it to a cache. It is then profitable for the mother to move any remaining juveniles after the weasel leaves and before it returns. This would limit the impact of predation to only one juvenile per attack and contribute to increased survival in juveniles from the litter. If predators fed upon young directly in the nest, this relocating behaviour would not help with the survival of the young and would therefore not be adaptive in the context of predation.

No other predation on a juvenile red squirrel in the nest has been reported to our knowledge; nestling mortality has previously been attributed to exposure, starvation, disease, and maternal mortality (Stuart-Smith and Boutin 1995). According to Krebs et al. (2001, page 207), "when in a nest, squirrels are simply unavailable". Our observation provides evidence that even in a nest squirrels may be available, especially juveniles and it seems probable that weasels are the main predator with the ability to prey upon juveniles while in the nest.

As stated above, parasitism may also play a role in the existence of the relocating behaviour by red squirrel mothers. Further investigation is needed to better understand the adaptive pressures behind the existence and maintenance of such behaviour, but based on our

observations and the apparent link between this relocating behaviour and nest disturbance, predation might be important.

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Evidence for Higher Soil Temperature and Potassium Promoting Invasion of the Common Dandelion, *Taraxacum officinale*, in Denali National Park and Preserve, Alaska

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Densmore, Roseann V. 2008. Evidence for higher soil temperature and potassium promoting invasion of the Common Dandelion, *Taraxacum officinale*, in Denali National Park and Reserve. *Canadian Field-Naturalist* 122(1): 67-69.

Common Dandelion, *Taraxacum officinale* ssp. *officinale* (dandelion) is expanding its range in Alaska and is of particular concern in National Park Service units. This study investigated the influence of estimated soil temperature, available potassium (K), available phosphorous (P), and total nitrogen (N) on dandelion cover and density on a site near the elevational limit of dandelion. The study site in Denali National Park had been disturbed by construction and was revegetated with native plants 12 years before the study. Seed input to the study site was abundant. In a multiple regression analysis, higher levels of estimated soil temperature and available K accounted for 79% and 73% of the variation in dandelion cover and density, respectively. Practical control methods include not fertilizing disturbed areas with K, and countering continued expansion of dandelion by monitoring human use areas and undisturbed habitats where soil temperatures are likely to be relatively warm.

Key Words: Dandelion, *Taraxacum officinale*, invasive plants, Denali National Park, Alaska.

Common Dandelion, *Taraxacum officinale* ssp. *officinale* (referred to hereafter as dandelion), is a common and widespread non-native plant that has spread from Europe to every continent except Antarctica. In Canada and the northern United States, dandelion is a weed in lawns and minimum till crops (Royer and Dickinson 1999; Stewart-Wade 2002). The range of this species has been expanding in Alaska (AKEPIC 2005; Hultén 1968). Dandelion is often the first invader in Alaskan National Park Service (NPS) units (McKee 2004), which have a mandate to conserve unaltered ecosystems and scenery. Alaskan national parks offer a valuable resource – millions of acres of native plant communities with no non-native plants. Dandelion invasion, in part, reflects the local effect of expanding human use accompanied by disturbance and dandelion seed input. In addition, the warming climate of Alaska, with increases in air and soil temperature and thawing of permafrost (ACIA 2005; Jorgenson et al. 2001) may be aiding dandelion expansion. Soil nutrient levels are also important in the establishment and growth of dandelion. Research in Great Britain and Minnesota has shown that the number and cover of dandelion plants in grasslands and lawns were much higher where fertilizer with potassium (K) was added or in lawn habitats that were high in K (Tilman et al. 1999), while increased phosphorous (P) also promoted dandelion, but was not as important as K.

The objective of this study was to evaluate the effect of soil temperature and nutrients on dandelion cover and density on a site near the range limit of dandelion in an Alaskan National Park. A primary goal was to evaluate whether revegetation methods that included seeding native legumes and fertilizing promoted dandelion.

Methods

The study site was located in Denali National Park and Preserve within the developed zone near the park entrance. Disturbance history, soil texture, and dandelion seed input were similar throughout the study site, but distribution of dandelion varied considerably. The study site was disturbed by road and airport construction from 1988 to 1991. The surrounding area had a large population of dandelion, and seed input to the study site was abundant. The study site was revegetated in 1991, and had not been redisturbed by further construction (Densmore et al. 2000). Most of the study site had been seeded with a mix of native legumes (*Oxytropis campestris* (L.) DC. (Field Locoweed) and *Hedysarum alpinum* L. (Alpine Sweetvetch)) and wheatgrasses (*Elymus* spp.). Most of the study site had also been fertilized in 1991 with Osmocote, a slow release fertilizer with a formulation of 14% nitrogen (N), 14% phosphorous (P), and 14% K, at a specified rate of 500 kg ha⁻¹. However, there were no records of how much fertilizer was actually applied; some spots were not fertilized and other spots were refertilized in subsequent years, thus increasing nutrient variation in otherwise similar soils. The study site included road cut and fill slopes that varied in slope and aspect, as well as more level disturbed areas.

In 2002, plots were established at 18 randomly selected sites. Slope and aspect were homogeneous within each sample site. The plots were 0.5 m wide, and varied in length from 2.5 m to 8 m, depending on the size of the site. Percentage cover of vascular plants by species and surface ground cover were measured with a line transect along one edge of the plot. Surface ground cover was estimated using non-overlapping categories of nonvascular plants, litter, and bare ground (soil and

TABLE 1. Summary of study plot variables.

	Mean (SE)	Range
Dandelion cover (%)	15.3 (4.3)	0.0-22.5
Dandelion density (plants/m ²)	30.6 (8.6)	0.0-114.0
Equivalent latitude ^a (°N)	65.6 (2.1)	52.5-79.7
Soil		
Total N (%)	0.08 (0.01)	0.03-0.15
Available P (ppm)	6 (1)	1-12
Available K (ppm)	51 (4)	29-89

^aEquation 1.

gravel) to equal 100% cover. Density of dandelion plants was measured within the whole plot. Some plants of the native subspecies, *Taraxacum officinale* ssp. *ceratophorum*, were present and were excluded from the measures of dandelion cover and density. The native subspecies was readily distinguished by the presence of conspicuous horns on floral bracts. Dandelion voucher specimens were deposited at the University of Alaska herbarium. Slope and aspect of each plot were measured. A soil sample was taken adjacent to the midpoint of each plot in August 2002. Each sample was the contents of a hole 15 cm in depth and diameter. The soil fraction (particle size < 2.0 mm) was analyzed for total N, available P, and available K. Nitrogen content was determined by Kjeldahl analysis (Bremner and Mulvaney 1982). Extractable P was measured with the Olsen (Olsen and Sommers 1982) or Mehlich III method (Tran and Simard 1993), depending on pH. Extractable K was measured with the Mehlich III method, which is correlated with plant K uptake (Bates and Richards 1993). The University of Alaska Agricultural and Forestry Experiment Station did all soil analyses.

The Statistical Analysis System (SAS) was used for data analysis. Dependent variables were dandelion cover (%) and density (plants/m²). Independent variables were equivalent latitude, and soil total N (%), available P (ppm), available K (ppm). For each transect, slope and aspect were used to calculate equivalent latitude, an estimate of potential insolation and an effective predictor of soil temperature in interior Alas-

ka (Dingman and Koutz 1974). The potential insolation of a surface is the quantity of solar energy that a surface would receive in a specified time period. If a restricted area is considered over a specified time period, then the relative potential insolation between points depends only on inclination (slope) and azimuth (aspect). The concept of equivalent latitude as an index of potential insolation is based on the fact that every slope is parallel to a horizontal plane on the earth's surface, and receives the same potential isolation as that plane. The latitude of that plane is called the equivalent latitude, θ' , and it depends on the inclination, k , and azimuth, h , of the slope as follows:

$$\theta' = \sin^{-1}(\sin k \cos h \cos \theta + \cos k \sin \theta)$$

[1]

where k is measured in degrees downward from the horizontal, h is measured in degrees clockwise from North, and θ is the actual latitude of the area in degrees.

Relationships among dependent and independent variables were examined with scatter plots and Pearson correlation coefficients with results considered statistically significant at $P < 0.05$. Multiple regression analyses were then used to determine the best model for predicting the variation in dandelion cover and density.

Results and Discussion

Dandelion cover and density varied considerably between plots, even though disturbance history and seed input were similar (Table 1). Dandelion cover ranged from 11 to 22% on 28% of the plots, 1-10% on 50% of the plots, to no dandelions on 22% of the plots. Dandelion density, measured as plants m⁻², ranged from 51-114 on 22% of the plots, 26-50 on 22% of the plots, 1-25 on 39% of the plots, to no dandelions on 17% of the plots. Other non-native species occurred in only 11% of plots, with low mean (\pm SE) cover (0.2 (0.2) %).

Dandelion cover was significantly correlated with equivalent latitude, and with soil levels of available K and P, while dandelion density was significantly correlated only with equivalent latitude and soil K (Table 2). All soil nutrient variables were correlated with each other. The sample size was relatively small ($n = 18$),

TABLE 2. Pearson correlation, r , matrix of dependent and independent variables on study plots. Correlations significant at a level of $P < 0.05$ are listed in bold type. $n = 18$.

Variable	Dandelion cover (%)	Dandelion density (plants/m ²)	Equivalent latitude (°N) ^a	Soil	
				Total N (%)	Available P (ppm)
Dandelion cover	1.00				
Dandelion density	0.89	1.00			
Equivalent latitude	-0.66	-0.73	1.00		
Soil					
Total N	0.38	0.39	-0.05	1.00	
Available P	0.55	0.39	-0.22	0.79	1.00
Available K (ppm)	0.68	0.52	-0.09	0.69	0.72

^aEquation 1.

but the multiple regression analyses demonstrated that equivalent latitude and soil K were the best predictors for variation in dandelion cover ($r^2 = 0.79$, $P < 0.0001$) and density ($r^2 = 0.73$, $P = 0.0002$). Our results agree with those of Tilman et al. (1999), who found that grass communities with higher K levels had more dandelions. They demonstrated that dandelion had a higher requirement for K than competing grasses, and hypothesized that high soil K levels tipped the competitive balance toward dandelion. In our study, however, higher soil K levels increased dandelion cover and density even though the cover of potentially competing species was relatively low and bare soil was available for dandelion colonization (Table 3). Therefore, adding fertilizer with K is likely to promote dandelion infestations even in areas with little or no competing vegetation. Soil levels of available P were also significantly correlated with dandelion cover, but the relationship with K was stronger. Because K and P levels were significantly correlated, our field data would have to be supplemented with controlled experiments to further define the role of these nutrients. The data we do have supports Tilman et al. (1999), who found that P also promoted dandelion, but was less important than K. The range of soil total N in the study area did not affect dandelion cover or density.

Dandelion cover and density also increased with equivalent latitude. We consider this to be a response to soil temperature because equivalent latitude is based on slope and aspect, and has been shown to be a good predictor for soil temperature in interior Alaska. Other soil variables such as texture were similar among samples. Dandelion benefits from warmer soils for growth and for carbohydrate and N storage in its taproot (Cyr et al. 1990). Currently, in Alaska, dandelion extends north to 67.8° latitude, and has recently expanded its elevational range to 1121 m along the roadside in Denali National Park and Preserve. Continued climate warming is likely to increase the cover of dandelion within its current range, and promote invasion of new areas. Monitoring and immediate eradication may protect National Park Service units and other wildlands that are not currently infested with dandelion.

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TABLE 3. Vegetation and ground surface cover (%) on study plots.

	Mean (SE) ^a		Range
Vascular plant cover ^b	37.6	(4.4)	7.5-89.0
Ground surface cover ^c			
Nonvascular plant	25.4	(6.2)	7.0-50.0
Litter	27.2	(7.2)	1.0-64.0
Soil and gravel	47.6	(5.7)	0.0-91.0

^a $n = 18$ plots.

^b Vascular plants other than dandelion.

^c Nonoverlapping categories that total 100%.

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Nocturnal Behavior of the Common Loon, *Gavia immer*

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Very little is known about nocturnal activity of Common Loons (*Gavia immer*). Knowledge of both diurnal and nocturnal behavior is needed to gain a complete understanding of their ecology. I used night vision light intensifiers to observe nocturnal behaviors of Common Loons. Results were consistent with the hypothesis that, as visual predators, loons would not forage at night and also that they would spend the majority of their time resting (92%). Loons, however, were just as active locomoting (patrolling) during the night as they were during the day. This suggests daily energy budgets need to be reexamined to incorporate this overlooked aspect of loon behavior. Lastly, loons on large lakes with multiple loon territories spent more time locomoting than loons on lakes that had just a single pair.

Key Words: Common Loon, *Gavia immer*, nocturnal behavior, Wisconsin.

Although there have been several diurnal time-activity budget studies of Common Loons (*Gavia immer*) (Evers 1994; Mager 1995; Gostomski and Evers 1998; Paruk 1999a), nocturnal behaviors have not been examined (McIntyre and Barr 1997). For obligate diurnal foragers, day length imposes strict limits on available foraging time (Lewis et al. 2005). Previous investigations of nocturnal foraging in sea ducks (tribe Mergini) concluded foraging dives are greatly reduced or non-existent (Nilsson 1970; McNeil et al. 1992; Guillemette et al. 1993; Lewis et al. 2005; Rizzolo et al. 2005). Barr (1973) had loons in captivity and did not observe any feeding in the dark.

During the breeding season, loons do vocalize at night, so some level of social communication is occurring during this time (McIntyre 1988; Wentz 1990). This opens up the possibility that loons may be active at night patrolling their territories. Knowledge of both diurnal and nocturnal activity is needed to gain a complete understanding of loon behavior.

The primary objective was to gain an understanding of nocturnal behavior exhibited by Common Loons through direct observation using night vision equipment. The following predictions regarding nocturnal loon behavior were examined: (a) that being visual predators of fish, loons would spend little to no time foraging at night; (b) they would spend most of the night resting or sleeping, and (c) they would sleep for longer bouts during the nocturnal hours than they do during diurnal hours. Lastly, comparisons between nocturnal and diurnal time activity budgets could be made which may potentially reveal unusual behavior.

Methods

Loons were observed in northern Wisconsin (46°N 90°W), Iron County, at several locations: Turtle Flambeau Flowage (TFF), Trude Lake, One Man Lake and Deer Lake. Descriptions of these lakes have been previously reported (Belant and Anderson 1991; Paruk 1999a). The former two lakes (TFF, Trude) are larger and each has multiple pairs of loons nesting in contrast to the latter two lakes (One Man, Deer), which

are smaller and have but a single pair of loons occupying the entire lake.

Loon pairs were studied 25 June to 15 August 1996 and 1 July to 15 August 1997. I chose to study loons later in the summer so as not to disrupt nesting birds, or pairs that had young chicks (< 7 days old). Eighteen individual adults from 9 pairs of loons were studied (four and five pairs in 1996 and 1997, respectively). Each pair was observed for 5 nights for a total of 45 nocturnal observations. Observation nights were not random, but limited to suitable viewing conditions: low wind (<12 mph), clear skies, and no rain. Each loon pair was observed every 5-8 nights. A Noctron-V Model 9878 night vision light intensifier (NVLI; Varo Inc., Garland, Texas) scope was used to observe the loons. It gathered much light from the lake surface and provided 3× magnification and a substitute 300 mm lens was also used to provide 6× magnification. The observation period was restricted to the nocturnal hours (22:00-04:30, 6.5 h). Observations totaled 290.5 h. Observations were made singly, or by a team of two. Individuals or teams generally did not remain for the entire duration of the night, but were replaced by a second individual (or team) generally at 02:00 h.

Loon behavior is easily observable as they occupy lakes and often remain in the open water (McIntyre 1988; Evers 1994). Previous diurnal time activity budgets have defined and established loon behavior into the following categories: foraging, resting, preening, locomoting (patrolling) and agonistic (McIntyre 1988; Evers 1994; Mager 1995; Paruk 1999a) and were adopted for the purpose of this study. If loons responded to the observer (team) by vocalizing (wail or tremolo), observations were postponed 15 min.

Loons were viewed continuously and their behavior was recorded for the 6.5 h time block. Following Evers (1994) only changes in behavior that lasted more than 30 s were recorded. For example, if a loon was resting, then swam for 15 s and then returned to resting, the behavior category was not changed. Individuals in the head-tucked position were considered sleeping (McIntyre 1988).

For statistical comparisons, all data were tested for normality. Arc-sine transformation was used to normalize the data. To avoid problems of pseudoreplication, specific behavioral categories were analyzed using a two-way ANOVA with repeated measures, with individual and behavior as the independent variables and the amount of time spent in each behavior as the dependent variable. Experiment-wise error rate was controlled at the $\alpha = 0.05$ level using the Bonferroni method of adjusting nominal alpha level by the number of tests performed (Sokal and Rohlf 1995).

Results

Loons did not forage at night (0%). They spent significantly more time resting (92.7%) than any other behavior, followed by locomoting (5.5%), agonistic (1.1%) and preening (0.7%), respectively ($F_{4,24} = 49.463$, $P < 0.001$; Table 1). While resting, loons were in the head-tuck position 26% of the time. The majority of the sleeping bouts lasted 15-25 min (76%; $n = 212$), although there was noticeable variation (4-54 min). Loons resting with their necks in an upright position appeared alert. For example, loons responded with alarm vocalizations to both a Great-horned Owl (*Bubo virginianus*) flying overhead and a Black Bear (*Ursus americanus*) on shore.

Loons spent significantly more time locomoting than in agonistic ($F_{3,24} = 6.137$, $P < 0.01$) or in preening behaviors ($F_{3,24} = 7.445$, $P < 0.01$). Direct agonistic observations occurred between territorial loons twice. In each case, loons from adjacent territories were swimming the periphery of their territory when they came in contact with each other. After initial contact, each loon made several short underwater dives. This was the only occasion loons were observed diving underwater.

Summary statistics show that loons on larger lakes with multiple loon pairs ($n = 14$) spent >200% more time swimming on the surface (=patrolling) compared to loons occupying smaller lakes with only a single pair of loons ($n = 4$) (7.1% vs. 2.6%; Table 1).

Discussion

It was suspected that loons, being visual predators, would not forage at night. This idea was supported by my investigation (Table 1). The absence of nocturnal foraging by loons suggests they are unable to do so. However, loons have been caught in nets in the Great Lakes set at depths at 60 m (Schorger 1947) so presumably they can forage in low light levels or possibly even in complete darkness. Some deep-diving sea ducks have been observed at depths > 40 m, but it is suspected they are primarily using tactile receptors (Guillemette et al. 1993; Lovvorn et al. 2003). Thus, it remains unclear whether loons are unable to forage nocturnally or whether they choose not to forage nocturnally. My study did not test for differences between these two competing alternatives, but nonprofitable nocturnal

foraging and visual constraints most likely force loons to avoid nocturnal foraging altogether. Future studies examining these alternatives would be useful to fully understand nocturnal foraging in loons.

The second prediction also held true, that loons spent the great majority of their time resting (>92%) during nocturnal hours. This is similar to the patterns observed in sea ducks (Lewis et al. 2005; Rizzolo et al. 2005). However, compared to diurnal time activity budget studies, this is more than a 300% increase (92.7% 27.5%) (Mager 1995; Paruk 1999a). Loons with young rested in sheltered bays near shore whereas loons without young often rested farther from shore. Also, the third prediction held true in that loons spent overall more time sleeping during the nocturnal hours (96 min + 6.9 min; 6.5 hr) compared to diurnal hours (35 min + 5.8; 17.5 hr; J. Paruk, unpublished data). Also, the average sleeping bouts were longer during the night compared to the day. For example, the average sleeping duration during nocturnal hours was 24 min compared to 14 min during diurnal hours (J. Paruk, unpublished data).

After resting, the next most common behavior noted was locomoting, or swimming on the surface (5.5%). During the diurnal hours loons will move from one side of the territory to the other to investigate a disturbance (e.g., a sound, a camper, another loon) or simply to patrol the periphery of the territory (Evers 1994; Mager 1995; Paruk 1999a). During the nocturnal hours, a similar pattern was observed. For example, Paruk (1999a) showed loons patrol their territories about 8% of the time during diurnal hours and this study showed loons moved around their territories at night 5.5% of the time. This raises the question why are loons actively swimming at night? Several loon investigators have noted that loons lose their territory, in part, to intruders through usurpation (Paruk 1999b; Piper et al. 2000; Evers 2001; Paruk 2006). Turnover is higher on larger lakes with multiple loon territories (Evers 2001) which suggests there is more pressure there from conspecifics to defend and maintain territories. Although territorial disputes are often between or among neighboring loons, floaters or non-breeders are often involved in territorial skirmishes (Piper et al. 1997; Paruk 1999b; Evers 2001; Paruk 2006). In addition, it has been found that large lakes (>5 loon territories) generally contain many non-breeders or floaters (Evers 2001; Taylor and Vogel 2003*) and that some of these individuals eventually obtain a territory on these larger lakes (Piper et al. 1997; Paruk 1999a; Evers 2001). Further evidence to support this overall pattern is that agonistic behaviors were observed only on larger lakes with multiple loon pairs nesting.

Further research investigating nocturnal behavior between loons on large lakes with multiple loon pairs could prove useful in better understanding loon population dynamics.

TABLE 1. Summary of Common Loon nocturnal behavior ($n=18$ individuals; 9 pairs), Iron County, Wisconsin, 1996-1997.

Behavior	Overall (%, SE)	P-value	Large Lake* (%, SE)	Small Lake* (%, SE)
Resting	92.7, 1.0	<0.001	90.6, 0.8	95.8, 0.6
Locomoting	5.5, 0.9	<0.05	7.1, 0.6	2.6, 0.4
Agonistic	1.1, 0.8	>0.05	1.6, 0.9	0.7, 0.3
Preening	0.7, 0.6	>0.05	0.7, 0.5	0.9, 0.3

* $n=14$ for large lake and $n=4$ for small lake

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Swimming Eastern Chipmunks, *Tamias striatus*, and Hairy-tailed Mole, *Parascalops breweri*, in Kawartha Highlands Provincial Park, Ontario

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We report swimming Eastern Chipmunks, *Tamias striatus*, and a swimming Hairy-tailed Mole, *Parascalops breweri*, in southern Ontario in Kawartha Highlands Provincial Park. Although naturally swimming Eastern Chipmunks have been seen before, they have never been previously documented in the literature. Ours appears to be the first photograph of a swimming Hairy-tailed Mole and the first report of one successfully and apparently voluntarily swimming.

Key Words: Eastern Chipmunk, *Tamias striatus*, Hairy-tailed Mole, *Parascalops breweri*, natatory behaviour, swimming.

Eastern Chipmunk

While canoeing in Kawartha Highlands Provincial Park, Peterborough County, Ontario, in August 2006, we saw at least two swimming Eastern Chipmunks. On 28 August 2006, at about 1700 hr, we watched one scout out the water's edge of a small rocky island (circa 75 m²) at the southern end of Vixen Lake (44°38'37"N, 78°12'31"W). The chipmunk jumped into the water at the place giving it the shortest possible crossing to the mainland, a swim of about 6-7 m. On 29 August 2006 at 12:00 noon, we watched another Eastern Chipmunk swim from the north shore of Long Lake to the large island in the middle of the lake (44°41'20"N, 78°10'31"W). This was a 40-45 m crossing, with a 10 knot cross-wind. Its shoulders were paddling at an impressive rate. Both chipmunks swam with the same style, with a huge proportion of their bodies (or, at least, fur) above water. From the tip of their nose to the tip of their tail, a continuous line of fur was above water except for a very small gap at the base of the neck and base of the tail. It was sunny at the time and place of both swims.

We saw an Eastern Chipmunk crossing at the narrows on the southern end of Vixen Lake during late evening on 28 August 2006, but it was too dark to positively identify the animal. During the day, we have seen individuals on the small rocky island that this narrows separates, indicating that these Eastern Chipmunks must be swimming to and from this island.

The swimming chipmunks we saw must have been extremely vulnerable to predation, swimming high out of the water on bright sunny days, with Great Blue Herons (*Ardea herodias*) usually nearby at both sites, and frequently swimming individuals of the Eastern Rat Snake, *Pituophus spiloides* × *alleganiensis*, (synonym *Elaphe obsoleta*) and Northern Water Snake, *Nerodia sipedon*, at the Vixen Lake site. Great Blue Herons are generalist predators that feed on mammals as large as 15 cm long Muskrats, *Ondatra zibethica*

(Kirkpatrick 1940; Godfrey 1966). Eastern Rat Snakes eat Eastern Chipmunks (Weatherhead et al. 2003). There are no records of Northern Water Snakes eating Eastern Chipmunks, although they may do so (John Himes, personal communication). Hairy-tailed Moles (*Parascalops breweri*) are also occasionally eaten by snakes, albeit water moccasins, *Agkistrodon mokasen* (Eadie 1939), whose range does not extend as far north as Ontario.

None of the local naturalists, including the owners of the Long Lake Lodge, had ever seen chipmunks swimming before. However, Eastern Chipmunks are known to rarely swim, especially when there is a dearth of food (Jeff Skevington, personal communication). This is consistent with the much larger ranges of individuals when food is scarce and smaller ranges during masting events of oaks [*Quercus* spp.] (Mares et al 1976; Lacher and Mares 1996). Contrary to our observations of swimming chipmunks, summer of 2006 was a masting year for oaks in Ontario, in which Jeff Skevington did not see or expect to see any chipmunks swimming in northern Ontario (personal communication). Eastern Chipmunk ranges are also known to expand in autumn, but not as early as August (Forsyth and Smith 1973).

There exist several published accounts of swimming chipmunks (e.g., Wilber and Weidenbacher 1961; Dagg and Wilson 1972), but each of these studies consists of researchers dropping mammals into a pool of water to ascertain whether and how well they swim. We have not found any published reports of chipmunks swimming without being dropped into water by humans. We are, therefore, providing the first known documentation of Eastern Chipmunks swimming naturally and voluntarily.

Hairy-tailed Mole

On 30 July 2007 on Long Lake, we saw a Hairy-tailed Mole, *Parascalops breweri*, swimming across the lake (44°41'27"N, 78°09'53"W). This was roughly



FIGURE 1. Swimming Hairy-tailed Mole, Long Lake, Kawartha Highlands Provincial Park 30 July 2007.

a half kilometer further east along Long Lake than where we saw the swimming chipmunk, roughly one hundred meters east of the islands in the middle of the lake. This mole was swimming in a relatively straight path from south to north and was photographed at least 20 m, and probably 25 m, from shore at 2:15 pm on a cloudy day (Figure 1).

Hairy-tailed Moles are usually found in areas with well-drained soils, not the Canadian Shield, although some locales listed in Dobbyn (1994) are on the Shield. Individuals almost invariably remain underground hence are usually never seen (van Zyll de Jong 1983; NatureServe 2008*). Male Hairy-tailed Moles often leave their tunnels during the breeding season, but this occurs in April in Ontario (NatureServe 2008*), consistent with breeding in late March and early April in southern New Hampshire (Eadie 1939). Summer is far from the breeding season, making our sighting on 30 July very unexpected.

The only other species of mole native to the Kawarthas, the Star-nosed Mole, *Condylura cristata*, is a good swimmer (van Zyll de Jong 1983; Dobbyn 1994). However, neither its nose nor tail resembles that of the Hairy-tailed Mole. The Eastern Mole, *Scalopus aquaticus*, is also native to Ontario, but its range does not extend to the Kawarthas. The Eastern Mole is found only in the far southwestern portion of the province, in Essex County and the Municipality of Chatham-Kent, which is 500 kilometers from Long Lake (Dobbyn 1994). There is at least one report of an Eastern Mole swimming (Hanawalt 1922), but its technique

is different from that we saw in the Hairy-tailed Mole. The Eastern Mole apparently only uses its rear legs for propulsion while swimming, while its front feet are held together like a prow for steering. By contrast, the Hairy-tailed Mole at Long Lake was clearly using both its front and rear legs for propulsion, as can be seen in the figure, and as also reported by Foote (1941).

There only seems to be one published report of a swimming Hairy-tailed Mole that was not intentionally dropped into water by humans (Foote 1941), but it was apparently not swimming of its own volition. Foote implies that the mole accidentally fell into the river and was swimming in circles while being helplessly carried to its death by the incoming tide (at least until killed by Foote and his companions). While the Hairy-tailed Mole we observed may have accidentally fallen or have been chased into the water, it was swimming across a narrow lake with no currents or tides and was making clear progress, moving in a relatively straight line that was the shortest path (circa 50 m) between south and north shores of Long Lake.

Discussion

This appears to be the first documented report of voluntary and successful swimming of Eastern Chipmunks and Hairy-tailed Moles. All previous reports for Eastern Chipmunks are of humans intentionally placing animals in water. The one previous report of a swimming Hairy-tailed Mole was of an individual swimming in circles while being carried by the tides to its apparent death. Our observations are consistent

with other species of typically non-swimming North American mammals, such as the Groundhog, *Marmota monax*, in that the animals might be good swimmers, but only do so rarely (Johnson 1923; Chapman and Feldhammer 1982). We suspect that Eastern Chipmunks swim as foraging strategy, although this guess is somewhat vitiated by the abundance of acorns in summer 2006 and the ubiquity of aquatic chipmunk predators. We are unsure what might have motivated the Hairy-tailed Mole to swim, other than to possibly escape an even less-aquatic predator or the mole's inability to locate the direction of the shore upon accidentally falling into the lake.

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ADDENDUM

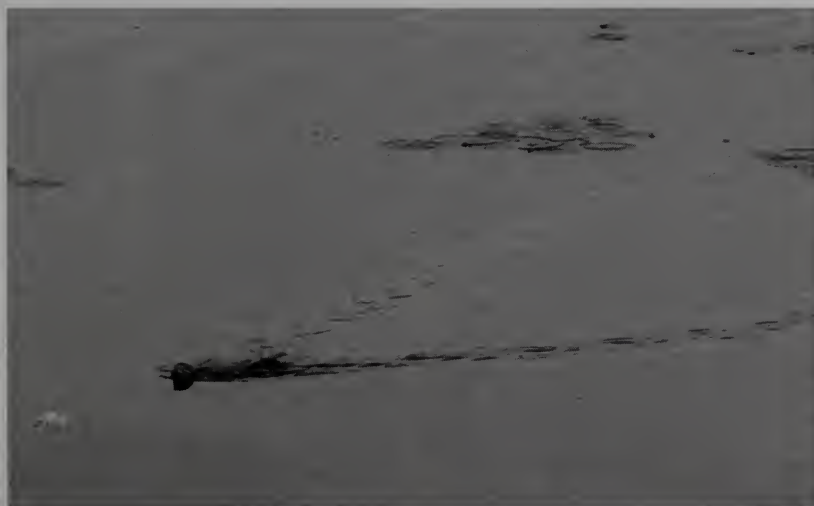


FIGURE 2. An additional observation of a swimming Eastern Chipmunk photographed by Root Gorelick while it was making a 6-7 meter swim at the south end of Vixon Lake, Kawartha Highlands Provincial Park, Ontario 19 August 2009. Although the focus and the resolution are poor the photo clearly shows its swimming posture, with much of the dorsal portion of its body out of the water.

Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming

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Jimenez, Michael D., Valpa J. Asher, Carita Bergman, Edward E. Bangs, and Susannah P. Woodruff. 2008. Gray Wolves, *Canis lupus*, killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming. Canadian Field Naturalist 122(1): 76-78.

Four cases where large predators caused Grey Wolf (*Canis lupus*) mortality are recorded. We describe two incidents of Cougars (*Puma concolor*) killing Wolves in Montana and one incident of a Cougar killing a Wolf in Alberta. We report the first recorded incident of a Grizzly Bear (*Ursus arctos*) killing a Wolf in the western United States.

Key Words: Gray Wolf, *Canis lupus*, Cougar, *Puma concolor*, Grizzly Bear, *Ursus arctos*, predation, interspecific interactions, Montana, Alberta, Wyoming.

Cougar (*Puma concolor*), Grizzly Bear (*Ursus arctos*), Black Bear (*Ursus americanus*), and Gray Wolf (*Canis lupus*) populations coexist in the Rocky Mountains of the United States and Canada. Reports of interactions between Wolves, Cougars, and bears are limited and most observations are anecdotal (Ballard et al. 2003). Wolves periodically usurp Cougar kills (U.S. Fish and Wildlife Service 1995; Ruth and Hornocker 1996; Ruth 2001) and occasionally kill adult Cougars (Schmidt and Gunson 1985; Boyd and Neal 1992; Jimenez, unpublished data) and Cougar kittens (White and Boyd 1989; Jimenez et al. 2006). Murphy et al. (1999) predicted that because Wolves travel in packs outnumbering Cougars, it is more likely for Wolves to kill Cougars than Cougars to kill Wolves. Cougars frequently kill domestic dogs; however, reports of Cougars killing Wolves are rare (Mexican Wolf Blue Ridge Adaptive Management Oversight Committee and Interagency Field Team 2005). We report two incidents of Cougars killing Wolves in Montana and one incident of a Cougar killing a Wolf in Alberta.

In 1995 and 1996, 35 Wolves were relocated from British Columbia and Alberta, Canada, to the Frank Church Wilderness Area in Central Idaho. Wolf #B-4, an adult female Wolf captured on 10 January 1995 at Petit Lake, Alberta, was released on 14 January 1995 in the Corn Creek drainage near Salmon, Idaho. By the end of February 1995, Wolf B-4 was located near the town of Drummond, Montana, approximately 185 km from the release site. Radio contact was lost on 17 November 1995, but we picked up a mortality signal in mid-January 1996 in that same vicinity. The dead Wolf was buried under approximately 60 cm of hard-packed snow in mountainous terrain covered by dense timber. We sent the frozen Wolf carcass to the U.S. Fish and Wildlife Service Forensics Lab in Ashland, Oregon. A necropsy revealed head trauma and a punc-

ture from a canine tooth through the top of the Wolf's skull. The Wolf had been killed, but not fed on, by a Cougar. From the time B-4 was released in 1995 until her death in 1996, we saw the Wolf one time and she was traveling alone.

On 29 January 2003, the radio-collar of female Wolf #297f from the Mill Creek Pack was located on mortality mode in the Paradise Valley, north of Gardiner, Montana. The pack consisted of three adults and four pups/yearlings. Investigation the following day found tracks of two Wolves traveling in 15-20 cm of snow along a two-track road in a mixed conifer forest. A barbed wire fence paralleled the road with briar bushes grown into it. Considerable amounts of Wolf hair and blood were found on the fence and on a bush. Tracks in the snow indicated that two Wolves were walking down the road but then both began to run. One set of Wolf tracks veered into the timber. The second set went through the barbed wire fence where the blood and hair were found. Drag marks in the snow led to a pile of 10 cm deep needles that covered the dead Wolf. Tracks indicated an adult Cougar with one or possibly two kittens had fed on the Wolf carcass. Punctures in the Wolf's hide and massive hemorrhaging were found on the neck and trachea. It was unknown if capture and handling twelve days earlier hindered the Wolf's flight, but we suspect that the Wolf running through the fence contributed to the Cougar catching and killing it.

A young, healthy, male Wolf #SR1 was fitted with an Argos satellite collar 18 November 2005 west of Turner Valley, Alberta, Canada. Wolf #SR1 appeared to be moving normally following capture until late February when daily locations localized in a 10 km² area. On 16 March 2006, Fish and Wildlife staff investigated the area and located the remains of #SR1 which included all four legs, head, tail, intestines, and stom-

ach cached under leaves and grass. Tracks in the snow indicated that a Cougar had been using an old farm shed at the site for shelter. It appeared that #SR1 traveled through the abandoned farm site and investigated the small shed where the Cougar was taking refuge. The Cougar attacked the Wolf and chased it through an open grassy area for approximately 50 m. Fresh blood was found where the Cougar made contact with the Wolf near trees at the edge of the grassy area. The Wolf was dragged by the Cougar approximately 130 m northwest and was cached in an area of thicker tree cover. Wolf hair was identified in Cougar scat found in the old farm shed. A necropsy of the Wolf remains revealed massive hemorrhaging in the muscle mass of the left jaw and a large fracture of the left dorso-ventral side of the skull.

Wolves and bears normally avoid each other; however, Wolves killed Black Bears in Alberta and Minnesota (Rogers and Mech 1981; Horejsi et al. 1984) and consumed denning Black Bears in Manitoba (Paquet and Carbyn 1986). Aggressive interactions between bears and Wolves are often associated with bears usurping ungulate carcasses from Wolves (Murie 1944; Ballard 1980; MacNulty et al. 2001; Ballard et al. 2003; Smith 2005) and defending young (Joslin 1966; Hayes et al. 1992; Ballard et al. 2003). A Brown [Grizzly] Bear killed a Wolf after usurping the carcass of a Moose (*Alces alces*) killed by Wolves in Alaska (Ballard 1980). We report the first recorded incident of a Grizzly Bear killing a Wolf in the western United States.

In summer 2005, we monitored a Wolf pack consisting of four adults and four pups, near Jackson, Wyoming. We placed an Argos satellite collar on a two-year-old Wolf and collected location data 4-24 times per day. Two clusters were less than a mile apart, indicating that Wolves had been there for 48 hours. We discovered the carcass of a yearling Moose at the first cluster. At the second cluster we found the fresh carcass of a 20-22 kg female Wolf pup that had been dead approximately one day. Along the back of the Wolf were large punctures through the hide, extensive muscle tissue damage, and massive hemorrhaging on the inside of the hide. The spine was broken in several places. Fresh Grizzly Bear tracks were found at the Moose carcass and the Wolf pup carcass. Based on the presence of Grizzly Bear tracks and the injuries to the Wolf pup, we concluded the Grizzly Bear killed the Wolf pup.

After extensive literature review, Ballard et al. (2003) summarized that Wolves, Cougars, and Grizzly Bears are occasionally adversaries due to interference competition; however, exploitation competition between wolves and other large predators did not result in significant resource partitioning. Wolf mortality from Cougar and Grizzly Bear predation is rare, and therefore it does not appear to be a significant factor impacting Wolves at the population level.

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Dytiscid Beetle Remains Discovered in a Pellet from a Great Gray Owl, *Strix nebulosa*, Nest

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Kerr, Kevin C. R. 2008. Dytiscid beetle remains discovered in a pellet from a Great Gray Owl, *Strix nebulosa*, nest. *Canadian Field-Naturalist* 122(1): 78-79.

On 18 July 2007, near Goose Creek, south of Churchill Manitoba, a Great Gray Owl, *Strix nebulosa*, pellet that contained the pronotum and elytra of a predaceous diving beetle, *Dytiscus alaskanus*, was discovered at a nest.

Key Words: Great Gray Owl, *Strix nebulosa*, predaceous diving beetle, *Dytiscus alaskanus*, pellet, Goose Creek, Churchill, Manitoba.

On 18 July 2007, an owl pellet was recovered from the base of an active Great Gray Owl, *Strix nebulosa*, nest south of Churchill, Manitoba (58°40'28"N, 94°08'56"W). The pellet was within the size range reported for this species (Cramp 1985) and contained both the pronotum and elytra from an adult predaceous diving beetle (Figure 1). The beetle parts were identified as belonging to *Dytiscus alaskanus* (Coleoptera: Dytiscidae). This large (22-30 mm) species is known to be fairly common in the area (Larson et al. 2000; R. E. Roughley, personal communication).

The nest was located on the rafters of a dilapidated cottage adjacent to Goose Creek Road, approximately 5 km south of Akudlik Village in Churchill. This is at the northern range limit in Manitoba for this species (Lang et al. 1991). Only three pellets were recovered from the nest site. Few pellets fell to ground level due to the structure the nest was sitting on; no additional pellets could be recovered without disturbing the nest. Neither of the other two pellets collected contained any beetle parts. All three pellets were comprised mostly of small rodent remains.

Great Gray Owls feed primarily on voles and the remainder of their diet largely consists of other rodents and small mammals (Bull et al. 1989; Bull and Duncan 1993). Other items tend to include moderately-sized vertebrates (Bull and Duncan 1993). Bull et al. (1989) observed the remains of only five insects after analyzing 1923 pellets from Great Grays nesting in Oregon. Species of insects previously observed in Great Gray Owl pellets have been of questionable origin, as they could have been accidentally ingested with

other prey items. The beetle remains discussed here suggest that the insect was actively hunted.

Great Horned Owls have been observed hunting dytiscid beetles in southern Manitoba (Duncan and Lane 1988). Although these owls are commonly regarded as generalist predators, they feed primarily on small mammals (Marti and Kochert 1996). *D. alaskanus* can reach high population densities in early summer and adults are attracted to lights (Aiken and Wilkinson 1985). These factors, combined with its large size, could make these beetles a viable food source at certain times of the year. Nero (1980) relays anecdotal evidence that a Great Gray Owl once captured a dragonfly beneath a bright light. These findings suggest that Great Gray Owls might opportunistically supplement their diet with non-typical prey items when they are abundant.

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FIGURE 1. Photograph of the owl pellet described in text. The arrow indicates the location of the beetle pronotum. A penny has been included for scale. Photograph by Rick Turner.

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A Group Defense Incident Involving Juvenile Striped Skunks, *Mephitis mephitis*

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Wilcox, Jeffery T., and Brendan N. Larsen. 2008. A group defense incident involving juvenile Striped Skunks, *Mephitis mephitis*. Canadian Field-Naturalist 122(1): 80-82.

Striped Skunks (*Mephitis mephitis*) occasionally fall prey to various predators. To reduce the risk of predation, Striped Skunks have evolved multiple defensive behaviors and aposematic coloration. Several types of defensive behaviors have been reported for individual Striped Skunks, but never for a group of skunks. We describe a group defense incident in an encounter between four juvenile Striped Skunks and a perceived predator—a man on a motorcycle.

Key Words: Striped Skunk, *Mephitis mephitis*, group defense, aposematic, noxious.

Striped Skunks (*Mephitis mephitis*) are occasionally preyed upon by various predators (Walton and Larivière 1994), and may be tested repeatedly by more than one predator in each encounter (Larivière and Messier 1996). From a young age, Striped Skunks rely on a strong chemical defense (Cuyler 1924) and, when threatened, are capable of scenting—expelling a noxious, strong-smelling musk—from anal glands located under the tail. A direct hit by a stream of musk to the eyes or mouth of a predator may cause vomiting or temporary blindness (Cuyler 1924). Each skunk has a limited volume of musk to devote to these scenting incidents before temporarily exhausting its supply (Verts 1967).

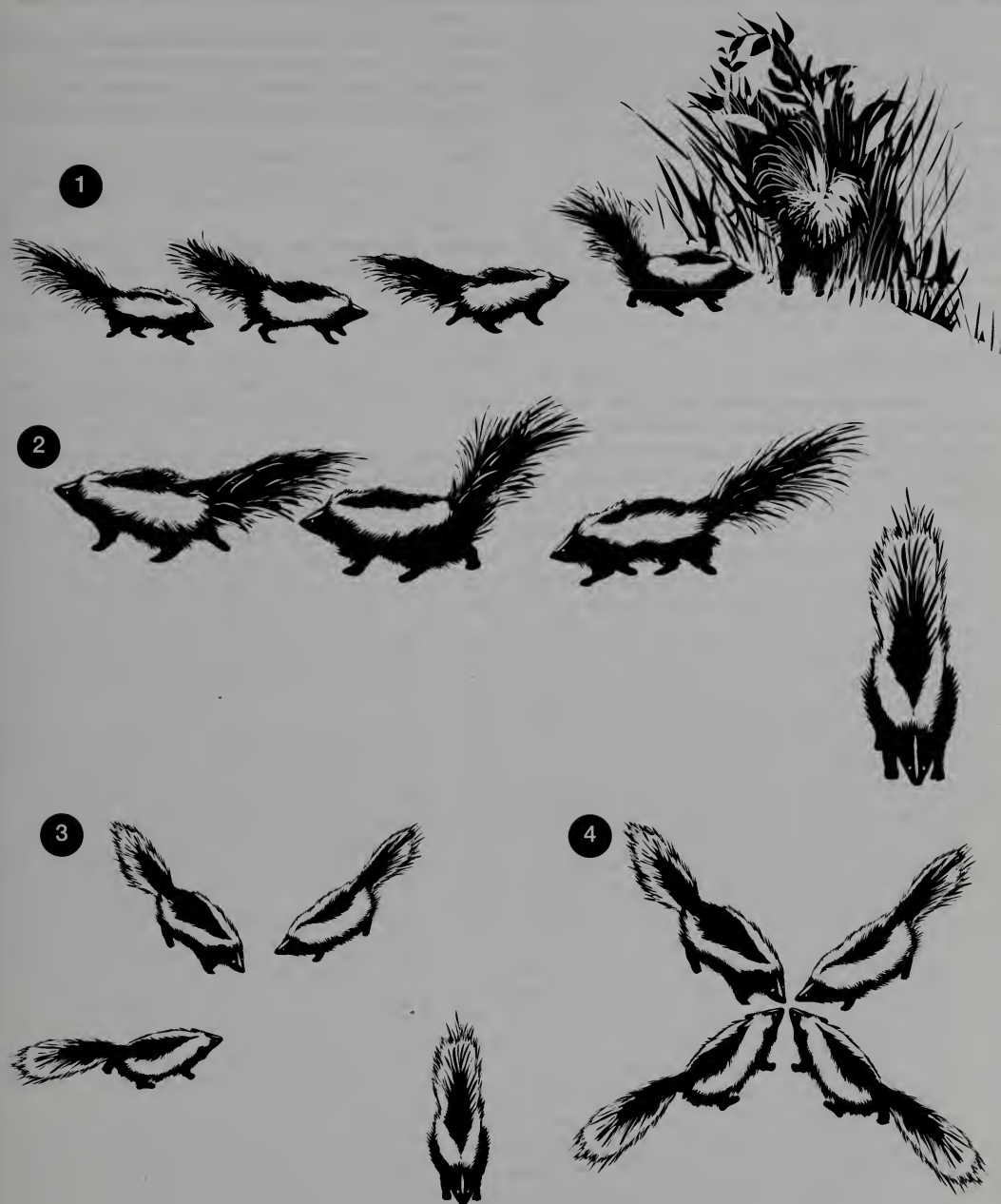
Skunks advertise their noxiousness through conspicuous morphological and behavioral traits known as aposematism. Aposematism is a visual signal to advertise unprofitability of prey, usually through bright warning colors set in bold patterns that contrast both with the background and with one another (Poulton 1889), making them conspicuous in most environments. Aposematic coloration benefits prey by reducing the frequency of encounters resulting in attack, and protects the predator by reducing time and energy spent pursuing noxious prey. The vivid, contrasting black-and-white pattern of Striped Skunks is an example of aposematic coloration.

Striped Skunks also display a wide array of defensive behavioral traits, such as abruptly changing direction (Larivière and Messier 1996), stomping their front feet, hissing, clacking their teeth, raising their tails in the direction of the predator, scenting, charging, fleeing, performing head stands with the anal area aimed at the predator, and hiding (Cuyler 1924; Laun 1962; Verts 1967; Walton and Larivière 1994; Larivière and Messier 1996). Until now, these defensive behavioral traits have been reported only for solitary individual Striped Skunks. Group defense in mammals is best known among rodents, ungulates, and primates, where prey species exhibit behaviors such as inspecting, scolding, or harassing a predator, and sometimes joint attack

and defense (Caro 2005). Here we provide the first report of a group defense behavior in Striped Skunks.

The encounter occurred between one of the authors (BNL), operating a small, slow-moving motorcycle, and a family of Striped Skunks attempting to cross a rural paved road on the afternoon of 12 May 2006, in northeastern Santa Clara County, California. The specific area is a transition zone between chaparral, oak woodland, and riparian habitats, with little understory, sparse annual grasses and forbs, and 80% canopy of Coast Live Oak (*Quercus agrifolia*) and California Bay Laurel (*Umbellularia californica*). While on his motorcycle, traveling southward approximately 150 meters from his residence at 21181 Alum Rock Falls Road, BNL encountered a family of five Striped Skunks walking south-southwest, perpendicular to the road and in single file, at the west end of Turkey Flat (37°23'53"N, 121°45'54"W). When first detected 50 meters distant, the lone adult skunk was approximately three meters ahead of the four juveniles, who kept an approximate 20-centimeter spacing between one another. As the motorcycle approached (at about 10 km per hour) to within 20 meters of the group, the adult skunk suddenly quickened its pace and disappeared into a thicket of Coyote Brush (*Baccharus pilularis*) 10 meters ahead of the juveniles (Figure 1). As the motorcycle approached to within three meters, the operator turned off the motor and stopped the vehicle. The young skunks were now caught in the open by a large, fast-moving "predator," so flight was likely a poor defense option. The lead juvenile skunk (approximately 15 cm, nose to rump) left the line, reversed its course, and advanced to within one meter of the motorcycle, confronting it (Figure 2). Seconds later, the remaining three juveniles turned, moved toward the first, and assumed a "tee" position, noses facing center about three cm apart and three cm off the pavement surface, hips elevated, and tails extended at a 45-degree angle (Figure 3). As the three remained motionless in this tee position the lead juvenile turned and joined the formation, keeping the same spacing and assuming the

FIGURES 1-4. Group defense by juvenile Striped Skunks. See text for details.



same pose as the original three, rump facing out. BNL observed that this arrangement was similar to the pinwheel defense exhibited by Musk Oxen (*Ovibos moschatus*) (Miller and Gunn 1984) and Wildebeest (*Connocheates* spp.) (Creel and Creel 2002), which present their defenses outward. In Striped Skunks, the threatening portion of the anatomy is presented from the posterior rather than the anterior end.

The skunks held this position for approximately 10 seconds as BNL remained motionless with the engine off. He was struck by the enhancement of the skunks' distinct black-and-white pattern as they formed a motionless "X" (Figure 4). After 10 seconds, the lead skunk glanced left at the motorcycle, lifted its right front foot, and moved its shoulders forward as if to walk away. The operator made a sudden movement

with his shoulders and the front wheel of the motorcycle, and the young skunk immediately resumed the cooperative group defense formation. This was repeated once more. On the third occasion, the operator let the skunks walk away. They formed a single-file line once again and walked swiftly into the Coyote Brush into which the adult had escaped. The skunks did not scent or vocalize during the entire incident.

Acknowledgments

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Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars AUD and so on. You will find these are the codes now used by financial institutions and internet currency converters. I will include an updated note for the next few issues as a reminder.

ZOOLOGY

Animal Life

Edited by C. Uhlenbroek. 2008. Tourmaline Editions Inc., DK Publishing Canada [American Museum of Natural History], 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7. 512 pages, 55.00 CAD Cloth.

If you are looking for a book to interest a teenager in the natural world [or an older person with a renewed opportunity to study wildlife], then this is the book for you. It covers the animal kingdom from dust mites to whales, from blood to senses and intelligence to behaviour. Each page is a collage of photographs, text or art work that provides a stunning visual experience.

The book has 21 major headings and about 75 "chapters." Each of these chapters covers two or so pages, with around 50 per cent being illustration. For example, "Scales" discusses the scales on fish, butterflies, reptiles and mammals. It explains how scales grow and shows 19 examples, with comments, from various animals.

Taxonomy is covered by a series of colourful diagrams using linked circles. Each circle is colour coordinated with the group it represents. In Animal Groups, vertebrates are orange and by seeking the orange tag on the top right of the page you get to a vertebrate page. Birds are coded purple, so you can now select the purple tagged pages for birds.

The book is packed with information. Each traditional class of animal has a page displaying photographs of representatives of all the major genera. For insects, there are beetles, bugs, moths, butterflies, ants, flies, grasshoppers and so on. In the attributes section, "Movement" covers walking, running, climbing, leaping, burrowing, slithering, sliding, flying, gliding and swimming. Where appropriate there are diagrams or graphs. Under "Breathing" [through lungs, spiracles, skin or gills], there is a graph of the dives by a Cuvier's Beaked Whale, showing it reaching 1900 metres. Under "Vision" you can see diagrams of how the eye is structured, the visible spectrum of light, and the difference between monocular and binocular vision, along

with seven photographs of very different eyes. The behavioural section covers hunting, feeding, defence, reproduction, raising young, societies, communication and intelligence. It is replete with pictures of animals fighting, scratching, migrating, building and digging.

The text has been written with great efficiency. No words are wasted, yet the message is clear and understandable. Younger children may need help with words like synchronous or pugnacious, but there are few such words. In general the authors use simple terms. However, each species depicted has a little table giving its Latin name and key characteristics.

As an editor I can see minor items I have issues with. The frog pages have a disproportionate representation of the gaudy tropical frogs over the common green-brown ones — it is not easy being green! I prefer to call *Naja haje* a Spectacled Cobra rather than an Egyptian Cobra. This snake has a wide distribution and, indeed, is now rare in Egypt. There is an inconsistent use of terms from the simple "odd-toed hooved mammals" [and not the scientific term Perissodactyla] to "Ranoides" [and not the simple "Typical Frogs"]. Some information is a little dated — the Bearded Tit is now called the Bearded Parrotbill. The type is very small, making it difficult to read for older people [I used magnifying glasses]. But these are really only editorial quibbles, and are not likely to be noticed by most people.

While much of the information will be known to experienced naturalists, they will still enjoy this book, because it is so well presented. And there will be some new knowledge for everybody. I did not know there is a frog that eats berries [instead of bugs!]. So this is a super book to give to a young person or even an older one who has just developed a thirst for nature. It will be fun to share with younger children and grandchildren. It reminds us all of the fascinating, complex, fragile and colourful world of the animal kingdom.

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Book Review Editor's note: Continuing with our decision to investigate suitable websites and, if appropriate, include their reviews, I have written the following review. If others know of similar suitable sites and are moved to submit a review please contact me at r.john@rogers.com.

HBW IBC

By Josep del Hoyo <http://ibc.hbw.com/ibc/>

The Internet Bird Collection is sponsored by *Handbook of the Birds of the World* [HBW], Lynx Edicions, of Barcelona, Spain, and is a video library of birds. It is arranged in taxonomic order by order and family using the scientific name. English names follow in parentheses for each family. For example, Struthioniformes is followed by Struthionidae (Ostrich). When you click the family you will reach a listing, ordered by genus, and giving the scientific and English names. This is a very simple way to get to your species of interest. The introduction page has current notes on the status of the website and should be read.

The site currently contains over 27 000 videos of 5350 species or about 55% of the known list of birds. Each video is typically 30 or so seconds long, but this varies. Some of the birds covered have several videos while others have only one or two. For example: there are 19 videos of the Great Blue Heron and only one of the Chinese Egret. But take care, while the Great Blue sequence shows 19 different birds (including #14 amusingly described as "A bird walking on water"), the five views of Guam Rail are actually four of the same bird and one of a zoo specimen. If you want to see typical action both are good, but offer little about plumage variation for the rail.

Once you are at the species level you need either the English as given in HBW or the scientific name. Thus you must use Crested Honey Buzzard instead of the more widespread Oriental Honey Buzzard (or *Pernis ptilorhyncus*). Heuglin's Gull is a little more difficult. Before it was split it was in the Lesser Black-backed Gull complex, so it is included as *Larus fuscus* ssp. *heuglini*, Heuglin's Gull, under video 10 of that species. Recent splits like the Indian Blackbird [*Turdus similis*] are not included. I was having problems finding the Brown-capped Pygmy Woodpecker, *Dendrocopus nanus*, until I discovered it as Brown-capped Woodpecker, *Dendrocopus moluccensis*.

Frog

By Thomas Marent. 2008. DK Publishing, 375 Hudson Street, New York, New York 10014 USA. 280 pages. 30.00 USD, 33.00 CAD.

This is a truly spectacular coffee table book 12 ½ by 11 ¾ inches by a master Swiss-born 42-year-old photographer who has travelled widely, often to remote areas, in his search for, and deep appreciation of, his subjects. His earlier books were *Butterfly* and *Rainforest*. The newest, *Frog*, is primarily built of over 400 spectacularly sharp colour photographs, often a full

Once you find your target species, you can then select from the list of videos available. These range in number from zero to over twenty. Each one is ranked, with five as the best. While five might mean the best photo, I often found the lower rankings more useful. The best photos were typically beautiful, close-up portraits of sitting adult birds. Lovely to look at, but not as informative of more distant shots of birds running through habitat or flying around. Zoo shots were the least useful, yet were better than none at all.

I have used this site for about a year now, generally for birds I hoped to see in the near future and with those actions I was not familiar (Greater Spotted Eagle, Greenish Warbler). I have also used it to verify identities of birds seen that cause uncertainty (Alder Flycatcher, Thayer's Gull).

The author of the site, Josep del Hoyo, makes frequent birding trips and brings back new videos. He is constantly adding to and upgrading the site. He has appealed to anyone who wants to share this task to supply a video. When he adds a video he also provides a link to the videographer. Here you can find a list of the donated videos and a short biography. Thus we can learn that Julien Rochefort of Paris has contributed 158 videos of European birds. Similar contributions have been made by others from around the world.

There is an option to play a "high quality" video, but I have been unable to connect to this feature. The quality of the "regular" videos is generally good and I have not the incentive to solve this problem.

This is a wonderful resource for all birders. It is particularly useful to open it twice and put the videos side by side. You can do this with birds that are difficult to separate (for example Chiffchaff and Willow Warbler) or two get two views of the same species under different conditions. And it will only get better.

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page for one individual or feature, of living amphibians. Most are frogs but with a few token salamanders—about 18 of the latter, on 13 pages (94-97, 132-133, 200, 268-273). A third group, the more secretive caecilians is not included. The salamanders selected are European (fire salamanders and newts) but the frogs range over the world. For these, a few European, North American, and Australian species are featured, but most are from the more diverse tropical frog faunas. Borneo, Madagascar, Peru, Colombia, and Costa Rica

are among the countries with included species. There are full top and side views of adults, but transforming juveniles, tadpoles and eggs and particular features such as eyes or skin are also included.

Marent emphasises in his introduction that there are some 6300 recognized species of amphibians, of which about 2000 are currently threatened with extinction due to habitat loss through human use expansion, exacerbated by co-increasing pollution, disease, collection for food or pets, and climate change. The text is sidebar photo captions inset throughout the book. Topics covered are identity (habitats, tree frogs, glass frogs, poison dart frogs, species variation: strawberry poison dart frogs, mantellas, other frogs, toads, newts and salamanders), body form (eyes, ears, nostrils, feet and legs, skin), survival (feeding, methods of movement, night versus day, camouflage, using poisons, last line of defense, unwanted competition) and reproduction (life

cycle, attracting mates, mating, sexual differences, spawn, tadpoles, froglets, newt reproduction).

The text concludes with a three-page listing of a conventional division into amphibian families, with common name, distribution, size (number of species) and brief description. Finally, there is a comprehensive index of both common and scientific names and topics, and brief acknowledgments.

This is a beautiful and superbly produced book full of interesting facts which bring the reader closer to an appreciation of the uniqueness and colourfulness of living amphibians more quickly than any field guide or textbook on them, though the latter have vastly more detail.

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Rattlers, Peepers & Snappers

By Vince Franke and Jim Andrews. 2008. Peregrine Productions LLC at www.rpsdvd.com. DVD. 24.95 USD,

Subtitled "The first complete DVD guide to all the amphibians and reptiles that breed in New England", one disc covers 52 species in these groups dynamically and with immediacy not possible in a static book format. Included are the majority of the species that occur in eastern Canada and it is relevant for herpetologists and naturalists over all of northeastern North America.

It is an ideal learning or teaching tool. The subject is covered effectively and in depth in some three hours and includes, in individual sections, identification and life history of each species through diagnosis by live-action outings to view habitat and behaviour with discussion by a varied lot of researchers. As well there are fact sheets, quizzes, "resource pages" and the calls of each frog species. The amphibian program covers varied topics: spring migration, road crossings, vernal pools, stream salamanders, finding frogs, and Wood Frog research while the reptile program includes, snakes and skinks, Box Turtle research. Timber Rattlesnakes, worm snakes, tracking Racers, Copperheads, fall migration, turtle tunnels, and nesting turtles.

For this production Jim Andrews is joined by Vince Franke of Peregrine Productions whose superb field photography day or night, terrestrial or aquatic, is a

perfect companion for the commentaries by Andrews and others. Andrews has long established himself as Vermont's premier promoter of herpetology and spearheaded *The Atlas of the Amphibians and Reptiles of Vermont December, 2001* by James S. Andrews and 1400 dedicated volunteers and organizations (see book review *Canadian Field-Naturalist* 116(4): 666-667).

The accuracy and immediacy of the new DVD is a model for any future efforts elsewhere. It promotes a greater understanding of these creatures, the immediate need and means for their effective conservation, and for the accurate recording of further observations to augment our understanding of their distribution and behaviour. Viewed in total or as short topical segments (individually readily accessible from the menu), the visual quality, the enthusiasm for the subject portrayed, and the accuracy and scope of the material presented are truly outstanding. From the casual to the serious, beginner to veteran naturalist, every viewer can gain from this production a greater understanding of the diversity and the conservation imperative of these fascinating animals and of the people who are their dedicated observers.

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BOTANY

Aromatic Plants in China

By Wang Yumei. 2008. Science Press, Beijing, China. 1069 pages, 180.00 CNY.

Aromatic plants are plants whose vegetative or reproductive organs are able to secrete or accumulate essen-

tial oil, volatile aromatic oil, or spice substances or volatilization-difficult balata used as the raw materials for daily life or industrial production. The majority of aromatic plants are seed plants. Volatile aromatic sub-

stances are secondary products generated through a series of enzymatic reactions in some aromatic plants. These substances may function to prevent or repel invasions of pathogens or pests, or to lure or attract pollination insects. The substances are usually secreted by glands, and exist in at least one of the organs, such as roots, stems, leaves, flowers, fruits and seeds. In plants, most of them are usually in free states, but some are combined with sugar, forming glycosides.

Aromatic plants usually contain four ingredients, aromatic, medicinal, nutrient and pigment. In addition, they sometimes also contain antioxidants and anti-bacterial ingredients, which not only increase their value, but also widen the area of use. They can be used as aromatic plants, medicinal herbs, food, ornamentals, or even as natural anti-bacterial or anti-corrosion agents or anti-oxidants.

In ancient times, Egyptians, Chinese, Mesopotamians, Greeks and Romans had begun to use aromatic plants for sterilization, anti-corrosion, medical care, health care, beauty and preservation of body, and so on. From the 13th century, distillation began to be the method used to extract oil from aromatic plants. Until the 16th century, Europeans successfully extracted essential oils, such as turpentine, rosemary oil, and lavender oil from the aromatic plants. Since the 19th century, with the development of science and technology, the exploration and use of the aromatic plants have rapidly expanded. So far, the world has discovered nearly 100 families, 200 genera, and more than 3600 species of aromatic plants, most of which are distributed in the tropical and subtropical regions. By the early 1980s, China had discovered more than 350 species of aromatic plants, among which about 150 species have been commonly used in the production of spices. The geographical distribution areas of the aromatic plants in China are over virtually all of the country. Some provinces and autonomous regions have become important bases for cultivation of aromatic plants.

Obviously, effective exploitation, utilization and protection of the aromatic plant resources need to recog-

nize the background information, summarize the present knowledge and carry out further researches in detail and in depth. The timely publication of the book *Aromatic Plants in China* meets such demand in at least some of these aspects. The book is a systematic and comprehensive monograph of the aromatic plant resources and their present status in China. The book was written based on countrywide data from an investigation on the aromatic plant resources, and the large amount of literature on the aromatic plants in China and abroad. The book is divided into two major parts, general introduction and special issues. The 632 color pictures are particularly helpful for readers to recognize and identify the aromatic plant species. In the first part, the basic knowledge of the aromatic plants, is introduced in categories of aromatic plants, their distributions, productions, main ingredients, functions, extraction, processing and uses, etc. In the second, the characteristics of each family, genus and species of the thousands of aromatic plants is given in detail, with Latin name, alias, English name, origin, distribution, biological characteristics, main points of cultivation techniques, main ingredients of essential oils, and the present situation of usage. At the end of the book, the strategies for the further exploitation, use and protection of the wild aromatic plant resources in China were put forward.

The book is suitable for the persons who engage in biology, agronomy, forestry, horticulture, plant chemistry, and other related scientific fields. Those who carry out investigation, cultivation, identification, research, processing, marketing, or use of the aromatic plants, will find it particularly useful. It will be valued by any persons who are interested in the aromatic plants.

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[Book Review Editor's note. Aweto is a Maori name for *Dong Chong Tsia Tsiao* (winter caterpillar summer grass). This is the caterpillar of a moth *Hepialus armoricanus* (Lepidoptera: Hepialidae) infected with an obligate fungus *Cordyceps sinensis* (Clavicipitales, Ascomycotina). The caterpillar lives underground in alpine grasslands in Tibet and the Himalayas for five years where it is attacked while feeding on roots. The fungus invades, killing and mummifying the larvae near the tops of their burrows. The 5-15 cm fruiting body emerges from the ground in spring from the forehead of the caterpillar, like "summer grass." The medicinal agent is likely *Cordycepin*, or 3-deoxyadenosine. Most aweto sold as pills in the west are probably fake or nearly so.]

Aweto in China

By Northwest Plateau Institute of Biology, CAS and Institute of Drug Quarantine of Qinghai Province, 2008, Shaanxi Science and Technology Publishing House, 744 pages, Price: 120 CNY.

Aweto is the complex of the stroma of *Cordyceps sinensis* parasitizing the larva of *Hepialus armoricanus* living through the winter. As a special organism, aweto is characterized by a worm in winter and a grass in sum-

mer, which is also the origin of its Chinese name. At present in the world, there are more than 400 species of fungi in the genus of *Cordyceps* parasitizing the larvae of insects, spiders and other organisms forming the carposporophyte, among which there are 68 species in China. In China, aweto resource is distributed in Sichuan, Yunnan, Guizhou, Gansu, Qinghai, Tibet and other areas.

Some scholars in China and abroad regarded all the fungi of *Cordyceps* parasitizing other types of organisms forming the carposporophyte as the aweto. However, the traditional Chinese medicinal theory, and most Chinese scholars, only regarded the aweto as *Cordyceps sinensis* parasitizing the larva of the organisms in Insecta, Lepidoptera, Hepialidae and *Hepialus* distributed in the alpine meadow areas of Qinghai-Tibet Plateau of China, form the complex of larva and fungi.

Aweto is one of the three most precious medicinal herbs and tonics. It is well known world wide due to its strange morphology, abundant nutrient, and magical medicinal effects. It is believed to benefit without the harm of ginseng. The ingredients of aweto are adenosine, mannitol, aweto acid, polysaccharides, and other bioactive chemicals. It is reported that the main pharmacological effects of aweto are regulation of human immunity functions, hormone-like effects, restraining cough, protection of kidney, strengthening the hematopoiesis, anti-aging, diminishing the rejection effects of organ transplants, inhibition of lupus, decrease of blood sugar, and anti-tumour properties. Among more than 800 Chinese medicinal herbs, aweto is the only type with dual effects of complement for both Yin and Yang according to the traditional Chinese medicinal theory. In ancient times, aweto was an exclusive tribute to the aristocracy in the royal palace in China.

In recent years, because of the high prices in the market, more and more people have plucked aweto in China, the so-called soft gold, unregulated, just like the "gold rush" in the western United States in the middle period of the 19th century. However, due to its scarcity in nature and the rapid increase in demand, the habitat of aweto were seriously damaged or even desertified. Aweto as a resource is decreasing rapidly and becoming more and more endangered. Nowadays, aweto has

been listed as a national key protected wild plant of level-II in China. The protection and research on the natural aweto resources are becoming imperative.

The book *Aweto in China* is the first comprehensive and systematic monograph on the various aspects of aweto resources in China, including the properties, biological basis, ecological characteristics, life history pattern, biological engineering, characteristics in herbal science and pharmacognosy, pharmacological effects, chemical ingredients, its role in health care, its other various applications, its research history and the present states of aweto resources.

The book contains 9 chapters, 41 sections, and more than 220 figures. The main contents are as follows: Chapter 1 fungus and aweto, Chapter 2 basic biological research on aweto, Chapter 3 ecological research on aweto, Chapter 4 research on the biological engineering of aweto, Chapter 5 chemical research on aweto, Chapter 6 herbal science and pharmacognosy of aweto, Chapter 7 pharmacological research on aweto, Chapter 8 roles of aweto in medicine and health care, and Chapter 9 research on the roles of aweto in biological control.

The book was well written with few errors, and can be easily understood by non-scientists. Abundant illustrations are helpful for readers to easily understand the explanations. The book is suitable for readers who engage in biology, taxonomy, agriculture, medicinal plants and other related fields, or other persons who are interested in aweto.

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Chinese Wild Orchids

By Chen Xinqi, Ji Zhanhe and Luo Yibo. 2008. Science Press, Beijing. 416 pages, Price: 260 CNY.

Orchidaceae is one of the largest and most diverse families in Angiospermae. Orchids have been regarded by some scholars as reaching the culmination of the evolution of plants. So far, Orchidaceae contains more than 700 to 800 genera and 25 000 to 30 000 species, and more than 100 000 hybrid species and varieties. In China, there are about 174 genera and more than 1300 species in Orchidaceae. Orchids are mainly distributed in Asia and America, especially Central and South America. According to the living habits and growth forms, orchids generally can be divided into three categories: the terrestrial orchids, epiphytic orchids, and saprophytic orchids (very rare in many other plants). In his classic work, Darwin (1862) used the theory of evolution to explain the adaptation and evolution of orchid plants based on a mass of facts and

detailed tests and observations. Although there were some mistakes in his explanations, most of the conclusions are still reliable nowadays. After Darwin, orchids have attracted more and more researchers all over the world.

Chinese orchids usually have beautiful slender leaves and faintly-scented flowers. The quiet elegance of orchids has been deeply advocated and praised by the Chinese people for thousands of years. The character of orchids was compared to a man of honour by Confucius in his book, *Dialogue at Home*. Orchids not only have been popularly used as ornamental plants, but some also have been used as medicinal plants, spices and so on. The cultivation of orchid plants has a long history in China and the world.

The wild orchid plants are not used intensively at present, but they are of potential value in the future, and they are also important as a natural gene pool.

Thus, from any point of view, the wild orchids should be protected in appropriate ways. However, in recent years, due to the rapid increase in the prices of orchids in domestic and international markets the wild orchid plants have been collected by people illegally. In addition, frequent and large scale logging and excessive land reclamation resulted in the habitats of wild orchid plants being destroyed or fragmented, and the number of valuable germplasm resources of wild orchids, especially the rare species, became endangered in some areas. Thus, the protection and rescue of the endangered resource of wild orchids in situ or ex situ is becoming more and more an imperative. The development of techniques for rapid propagation and cultivation of various orchid plants are also vital. In order to do this work more effectively, all-around recognition of past and current ecology and distribution of wild orchid plants is needed.

The book *Chinese Wild Orchids* is one of the largest and most comprehensive monographs illustrating the wild orchid resources in the world. The book was written in both Chinese and English, and includes 117 genera, 403 species and 2 varieties of Chinese wild orchids. The morphological characteristics, origin, habitat and

elevation of distribution, inflorescence time of each species was described in detail. Abundant first-hand information was included in the book. Most color photographs in the book were taken by the authors in the field, and many of them are being published for the first time. The book has strong scientific and practical values. Its publication will promote the research on orchids, exploitation and protection of the orchid resources, development of orchid industry, as well as the international academic exchanges in the field of orchids.

The book was written on the basis of textual research weighing almost every word. Abundant illustrations are helpful for readers to easily understand the explanations. The book is suitable for professionals who engage in botany, taxonomy, agriculture, forestry, horticulture, medicinal plants and other related fields.

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Book Review Editor's note: The American Orchid Society has recently published a series of beautifully-illustrated articles on Chinese orchids in its journal *Orchids*.

The Vascular Plants and Their Eco-Geographical Distribution in the Qinghai-Tibet Plateau Area

By Wu Yuhu. Science Press, Beijing, 2008, 1370pp, Price: 280.00 CNY.

The Qinghai-Tibet Plateau, with an average elevation of 4000 metres and covering an area of 2 300 000 square kilometres of land, is known as the "roof of the world" and the "Third Pole of the Earth". The formation and development of the Qinghai-Tibet Plateau since the Cenozoic is one of the most important events in the natural history of the Earth, because its uplift has a profound impact on the natural environment of vast adjacent areas. As a unique natural geographical unit and large ecosystem of the world, Qinghai-Tibet Plateau has become an ideal natural laboratory for carrying out research in the fields of geography, biology, ecology, resource and environmental science, and other related subjects.

The vast area and complexity of the environment of the Qinghai-Tibet Plateau provide diversified conditions for the growth and development of a large number of plant species. The complexity of the flora of the area lies in the abundant plant species, geographical elements and vegetation types. According to a rough estimation, there are about 10 000 higher seed plant species in the area. The area not only retains a number of ancient plant species, but also involves a lot of new plant species after the geological uplift. So far, the number of genera and species of the ferns, gymnosperms, and angiosperms being found in the Qinghai-

Tibet Plateau area accounts for 40% of the flora of China. Furthermore, nowadays the new records of plant species are frequently found in this area.

Since the 1850s, a number of foreign explorers and scientists successively carried out a variety of investigations in fields such as geology, geography, flora, fauna, as well as natural conditions and social customs, in the Qinghai-Tibet Plateau area, accumulating some preliminary information. From the 1950s, large-scale comprehensive scientific investigations organized by the central and local governments were carried out several times in the area, which laid a solid basis for studying the formation, evolution and natural resources of the Qinghai-Tibet Plateau area. Especially active were many botanists as backbone members participating in these investigations. They collected a large number of plant specimens, which became valuable data for the analysis of the flora of the area.

Based on the plant specimens collected in the Qinghai-Tibet Plateau area by former researchers, and the author's own first-hand data on the flora of the area accumulated in more than 30 years of investigations, as well as a large number of literature references in China and abroad related to the area, the book comprehensively addresses the vascular plants and their eco-geographical distribution in the Qinghai-Tibet Plateau area.

The book provides the Chinese and Latin names of each vascular plant family, genus and species currently found in the whole Qinghai-Tibet Plateau area, except for the area of Hengduan Mountains. For each vascular plant genus and species, the important morphological characteristics, the related primary literatures, distribution area, range of altitude and environmental characteristics are given in detail.

The book was scrupulously written and there are few errors. Abundant illustrations aid readers' understanding of the text. The book is suitable for professionals

who engage in botany, agriculture, forestry, geography and environmental resources and other related fields, as well as professional teachers and students, staff in production, application, and so on.

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ENVIRONMENT

A Primer of Conservation Biology

By Richard B. Primack. 2008. Fourth edition. Sinauer Associates Inc., Sunderland, Massachusetts, USA. 349 pages. ISBN: 978-0-87893-692-2. Paperback.

This textbook is a useful and up-to-date introduction to the rapidly growing field of conservation biology, written mainly for undergraduate university students. In fact, I have used the previous edition of this book in my own conservation biology course, at York University's Glendon College, for the last four years. Due to its reasonably concise and generally well-researched coverage of many current topics in this field of study, *A Primer of Conservation Biology* is particularly useful for a half-year, or a one-term, introductory course.

Richard Primack, a professor at Boston University and the current editor-in-chief of the reputable scientific journal *Biological Conservation*, has also authored a more detailed, longer textbook titled *Essentials of Conservation Biology*, and this more complex book is suitable for a full-year, more advanced course. In fact, the author has produced new editions of both of these textbooks every few years, since 1993. This poses a bit of a challenge to professors who have been using a particular edition of one of the textbooks for a longer period of time, since, just as one becomes comfortable with a current version of the book, a new, generally longer and reorganized, edition comes along. However, the new editions can be justified by the rapid accumulation of new facts and studies in this dynamic field of biology, and the author has done his best to include numerous very recent and important references in the latest (fourth) edition of the *A Primer of Conservation Biology* textbook. In comparison to the previous edition, the current version of the book contains almost twice as many chapters (there are nine chapters now, as opposed to five chapters in the third edition), but these chapters are generally shorter than the ones found in the third edition. As a result, the new textbook is only a little bit (29 pages) longer than the previous version – a modest and manageable increase in size, from the point of view of a professor planning a short course based on the book. Furthermore, unlike the previous editions, which had only black-and-white diagrams and

figures, the current book has all the illustrations in full colour, and this certainly makes the textbook more appealing to look at and browse through.

The book also has a good index and a useful glossary, including many key terms in ecology and conservation biology. The reference section is detailed and up-to-date, and virtually each reference listed here is followed by the book chapter or chapters where the study was initially cited – a nice and useful touch. A list of selected environmental organizations and sources of information about conservation issues is provided in an appendix.

As always, with such fairly general textbooks, experts can take issue with aspects of the particular coverage of certain controversial topics of current interest. For example, the discussion of introduced species offered on page 111 simply repeats some of the standard points often made by certain invasion biologists. The Purple Loosestrife is cited as an example of an exotic European species which is currently taking over marshes in North America. However, there is no mention of a major study by Hager and McCoy (1998), where the authors reviewed all the available information and found no solid evidence in support of the notion that this much-maligned exotic plant has a negative effect on our wetlands. In fact, it seems that many insect species, including native ones, feed on this plant species (Diehl et al. 1997; Guisasu 2008). Such information would add a bit of much-needed balance to this discussion. Primack also mentions that introduced worm species “are currently altering soil conditions across North America, with potentially enormous, but largely unknown, consequences to the rich native underground biological communities”. Well, since this is a scientific textbook, perhaps we should wait for conclusive scientific evidence before making such sweeping and largely unsubstantiated statements. If the impact of certain introduced species is not currently known, and we do not have any clear evidence that they are causing any harm to the environment, then we should not make assumptions about their potential “enormous” negative impacts. This only

reveals the currently fashionable anti-exotic species bias of certain researchers, rather than any useful scientific facts.

However, despite such occasional problems, this is a useful and reasonably thorough book, which can provide a wealth of well organized information both to biology students and to members of the general public interested in vital current issues in ecology and conservation biology.

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NEW TITLES

Prepared by ROY JOHN

† Available for review * Assigned

Currency Codes - CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars, GBP Great Britain Pound.

ZOOLOGY

Threatened Amphibians of the World. Edited by Simon N. Stuart, Michael Hoffmann, Janice S. Chanson, Neil A. Cox, Richard J. Berridge, Pavithra Ramani and Bruce E. Young. 2008. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 776 pages, 124.00 EUR Cloth.

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Marine Habitat Mapping Technology for Alaska. By J. Reynolds and H. Greene. Alaska Sea Grant College Program, Box 755040, University of Alaska-Fairbanks 99775 USA. Free – order online at : <http://seagrant.uaf.edu/bookstore/pubs/AK-SG-08-03.html>.

News and Comment

Michael Cheney 1956-2007

Mike Cheney of Masset, British Columbia, born 4 December 1956, died suddenly of a stroke 2 November 2007. His last published contribution "Cowbane. *Oxypolis occidentalis*, a new native vascular plant species recorded for Canada on the Queen Charlotte Islands, British Columbia" was co-authored with Kendrick L. Mar and appeared in *The Canadian Field-Naturalist* 121(4): 421-422 after his death. This find reflected a continuing interest in the biota of the Queen Charlotte Islands and the likely survival of some species there in unglaciated portions during the Pleistocene. He was senior author with Patrick Bartier and Barb Johnson of "The vascular plants of Haida Gwaii" published in 2007 by Gwaii Haanas National Park Reserve and Haida Heritage Site, Skidegate, British Columbia, 23 pages. He was involved with the Invasive Plant Council of British Columbia and produced a DVD documenting his efforts to control some of the large invasive "Knotweed" species by spraying them with seawater. Mike donated collections of both native and introduced species that were first records for the Queen Charlotte Islands to the herbarium of the Royal British Columbia Museum, Victoria,

British Columbia. He also collected specimens or tissues for DNA analysis, most recently to be used in a phylogenetic study of *Calamagrostis* in North America by Jeff Saarela at Canadian Museum of Nature, who is collaborating with Paul Peterson at the Smithsonian Institution.

Largely self-taught in botany; Dr. Cheney's passion for natural history was only one dimension of the man. He was also an Old Testament scholar, on the faculty of Athabasca University, and had received a Ph.D. in Old Testament Exegesis and authored "Dust, Wind, and Agony: Character, Speech and Genre in Job: An exploration of the Book of Job and its relationship to Egyptian and Mesopotamian literature" published by Almqvist and Wiksell in 1994. He is survived by his wife and two sons. See the personal tribute by Ken Marr, John Pinder-Moss and Richard Hebda (2008): "Fond memories of Mike Cheney..." BEN (Botanical Electronic News) # 389 [<http://www.ou.edu/cas/botany-micro/ben/ben389.html>] summarized here with additional information provided by Ken Marr, Curator of Botany, Royal British Columbia Museum, Victoria, British Columbia.

Marine Turtle Newsletter (119)

January 2008. 28 pages: ARTICLES: Directional Location in a Turtle Barnacle, *Chelonibia testudinaria*, on Green Turtles (J. Moriarty, J. A. Sachs & K. Jones) — Sea Turtle Bycatch by *Cerco-fixo* in Cananeia Lagoon Estuarine Complex, Sao Paulo, Brazil (S. M. Nagaoka, A. C. V. Bondioli, & E. L. de A. Monteiro-Filho) — Marine Turtle Nest Translocation Due to Hurricane Threat on Reunion Island (S. Ciccone, M. Lauret-Stepler, & J. Bourjea) — Loggerheads off Ecuador: Occurrence, Distribution and Bycatch from the Eastern Pacific Ocean (J. J. Alava) — NOTES: A Stranded Leatherback Sea Turtle in the Northeastern Mediterranean, Hatay, Turkey (B. Sonmez, D. Sammy, S. Yalcin-Ozdilek, O. A. Gonenler, U. Acikbas, Y. Ergun, & Y. Kaska) — Preliminary Study on Sea Turtles in Bintan Island, Riau Archipelago, Indonesia (C. Winata, A. Nadina, & M. Rofik) — Green Turtle Tag Recovery Further Links Northern Brazil to the Caribbean Region (E. H. S. M. Lima, M. T. D. Melo, M. M. Severo, & P. C. R.

Barata) — IUCN-MTSG QUARTERLY REPORT — MEETING REPORT — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <<http://www.seaturtle.org/mtn/>> or postal mail to Michael S. Coyne (Managing Editor) Marine Turtle Newsletter, A321 LSRC, Box 90328 Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: mcoyne@seaturtle.org.

The Library of the Swiss Orchid Foundation at the Herbarium Jany Renz

The **Renz library** is one of the finest and most complete orchid libraries, and is a cultural asset, now with a worldwide accessibility. The Renz library is a comprehensive reference collection of orchid literature, which serves as excellent basis for research, conservation and horticulture. The collection contains over 3000 volumes, including an irreplaceable collection of rare and antique folio volumes, which are considered to be among the best preserved copies in the world.

A complete reference of modern literature is a precious resource for the study of orchids, the largest family of flowering plants. The collection of separatates contains of around 5000 scientific articles from many sources and represents an

extraordinary comprehensive and versatile collection of literature on orchids. The complete library was incorporated into the online catalogue of the University Library of Basel, Switzerland, and is now available at <http://aleph.unibas.ch>

Some 90 select illustrated orchid books, containing over 7000 hand-coloured drawings, have been digitized during the last five years and may be accessed online on the website of the Swiss Orchid Foundation <http://www.orchid.unibas.ch> (see 'orchid books'). The rarity, originality and quality of these hand-coloured drawings is an invaluable source of information and proves that scientific precision and artistic efforts are not mutually exclusive. Scientific illustration is irreplaceable for

exact documentation, as neither computer science nor photography is able to present such a large amount of accurate and aesthetic information on a single sheet of paper. A large number of the hand-coloured drawings were used for first descriptions and are thus important for the interpretation of the scientific names of orchids.

In addition to the illustrations, over 52000 photographs of orchids from around the world have been scanned and their identity and names checked; they are available through the website of the Swiss Orchid Foundation. Herbarium specimens, drawings or photographs of all orchids from Europe, Asia Minor, North Africa and North America are available online. Images of many other Asian, Australasian, African, Madagascan and tropical American orchids are also available. This **World Orchid Iconography** an important tool to obtain identifications and nomenclatorial information on orchids.

Furthermore, the Foundation's website provides free access to *BibliOrchidea*, a comprehensive literature database with more than 140 000 entries, covering over 80% of the orchid literature available worldwide. The database is continually expanded and kept up-to-date by the eminent orchid specialist Dr. Rudolph Jenny. Scientists, horticulturists and conservationists, both professional and amateur, can find publications easily, either by searching for a specific title, author or year of publication or by browsing through a comprehensive list of keywords. First descriptions may be found by specifying the taxon (genus, species, subspecies, and variety). All results are accompanied by appropriate images from the Swiss Orchid Foundation database.

Sources of the digitized hand-colored drawings

- A Century of Orchidaceous Plants Vol. 1 (William Jackson Hooker)
- A Second Century of Orchidaceous Plants (James Bateman)
- Album des Orchidées d'Europe Deuxième Edition (Henry Correvon)
- Australian Orchids Vol. 1 & 2 (R. D. Fitzgerald)
- Blutenanalysen neuer Orchideen, III. Afrikanische und madegassische Orchideen 3 (R. Schlechter)
- Collectanea Botanica (John Lindley)
- Dictionnaire Iconographique des Orchidees (Alfred Cogniaux; Alphonse Goossens)
- Die Orchidaceen Deutschlands, Deutsch-Oesterreichs und der Schweiz (Max Schulze)
- Die Orchidee, Vol. 56(6), 2005 (Otto Möller)
- Die Orchideen Deutschlands und der angrenzenden Gebiete (Erich Nelson)
- Die Orchideen Europas (Helmut Baumann; S. Kuenkele; R. Lorenz)
- Die Orchideen von Java (& Figurenatlas Vol. 1) (Johann Jacob Smith)
- A Century of Indian Orchids (J. D. Hooker)
- Die Orchideen von Rhodos und Karpethos (C. A. J. Kreutz)
- Die Orchideengattungen Anacamptis, Orchis, Neotinea (H. Kretzschmar; W. Eccarius; H. Dietrich)
- Flore de Madagascar, Plantes Vasculaires, 49 Famille - Orchidees Vol. 1 & 2 (Joseph Marie Alfred Henri Perrier de la Bâthie,)
- Flore Illustrée de Nice et des Alpes-Maritimes, Iconographie des Orchidees (Jean-Baptiste Barla)
- Forest Orchids of West Africa (C.W. Chew)
- Genera and Species of Orchidaceous Plants Part IV (John Lindley)
- Genera et species orchidearum et asclepiadarum quas in itinere per insulam Java vol. 1-3 (Heinrich Kuhl; Johan Coenraad van Hasselt; Jacob Gijsbertus Samuël van Breda)
- Icones Orchidearum Austro-Africanarum Volume 1 "2 (Harry Bolus)
- Icones Plantarum Helvetiae (Albertus von Haller)
- Icones Plantarum Japonicarum (Carolus Petrus Thunberg)
- Iconografia delle Orchidee d'Italia (Text: Walter Rossi /Plates: Anne Elderedge Maury)
- Iconographie des Orchidees du Brésil (João Barbosa Rodrigues)
- Illustrations of Orchidaceous Plants (Thomas Moore)
- Lindenia Iconographie des Orchidées (All Volumes) (Lucien Linden & Emile Rodigas)
- Monographie des Orchidées des Iles de France et de Bourbon Vol. 1 (Achille Richard)
- Orchidées du Département de la Marne (Ch. Richon)
- Orchideen Deutschland (Walter Müller; F. Kränzlin)
- Orchidees de Madagascar, Orchidaceae Perrierianae Madagascariensis (Friedrich Richard Rudolf Schlechter)
- Orchidées des Iles Australes d'Afrique Vol. 1 (Louis Marie Aubert du Petit-Thouars)
- Orchids and how to grow them Vol. 1 (Samuel Jennings)
- Orchids of Africa, A Select Review (Text by J. Stewart ; Ill. by E.F. Hennessy)
- Orchids of Australia Vol. 1 (W.H. Nicholls)
- Orchids of South-Africa, Icones Orchidearum Austro-Africanarum, Vol.III (Harry Bolus)
- Paxton's Flower Garden, Vol. 1 - 3 (John Lindley; Joseph Paxton)
- Poeppig et Endlicher, Nova Genera Plantarum Vol. 1 & 2 (Eduardus Poeppig & Stephano Endlicher)
- Reichenbachia. Orchids illustrated and described (Frederick Sander)
- Rumphia Band 4 (Carl Ludwig Blume)
- Select Orchidaceous Plants First - Third Series (Robert Warner)
- Sertum Orchidaceum (John Lindley)
- Southern African epiphytic orchids (John S.Ball)
- The Genus Masdevallia (Florence Woolward)
- The native Orchids of Florida (Carlyle A.Luer)
- The native Orchids of the United States and Canada excluding Florida (Carlyle A.Luer)
- The Orchid Album Vol. 1 - 11 (Robert Warner; Benjamin Samuel Williams; T.Moore)
- The Orchidaceae of Mexico & Guatemala (James Bateman)
- The Orchids of the Cape Peninsula 2 (Harry Bolus)
- The Orchids of the Sikkim-Himalaya Vol. 1 - 3 (G. King and R. Pantling)
- The Slipper Orchids: Selenipedium, Phragmipedium, Criosanthos, Cyripedium, Paphiopedilum (Esmé Franklin Hennessy)
- Xenia Orchidacea (H.G. Reichenbach, F. Kraenzlin)

Small Remnants of the Rice Lake Plains Prove Important ... How Many Do We Need?

PAUL M. CATLING

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Catling, Paul M. 2008. Small remnants of the Rice Lake Plains prove important ... how many do we need? *Canadian Field-Naturalist* 122(1): 93-94.

Protecting large areas has a lot of well-documented advantages over protecting small areas, but small areas, especially with regard to rare plants, can be very important. This has been known for some time (e.g., Conner and McCoy 1979). One of the best articles about the long term species retention in very small areas is that of Reznicek (1987). In some situations it is possible to analyze data to test this "small area value" hypothesis, and data on remnants of the Rice Lake Plains is available to do it. (see Catling 2008).

Remnants of the plains with regionally rare and very restricted flora are known from the higher parts of the Oak Ridges moraine to the west, south and east of Rice Lake (Catling et al. 1992; Catling 2008). At least 42 relatively well-preserved and isolated remnants are known, and data on the total number of native species and number of regionally rare native species are available for 24. These remnants vary in

size from 0.1 to 16.7 ha and collectively contain 257 native species of which 111 are regionally rare.

A simple linear regression plot of species number and area for the 24 sites provides a trend line with significance values. (Figure 1). The line suggests that as size increases the number of species tends to increase. However, the model is not significant in either case (at $P=0.05$ level) and in fact is not even close to being significant ($P>0.16$). In these data, species-area relationship is not important. It is clear that some smaller sites such as 29 (a 1.64 ha remnant in and near Goodrich-Loomis Conservation Area) contain almost as much biodiversity as much larger sites such as 12 (8.82 ha of prairies and savanna at Alderville First Nation), and a number of small sites are positioned quite high above the line. The regionally rare species have presumably been present at these small sites for more than a hundred years, since the plains were largely

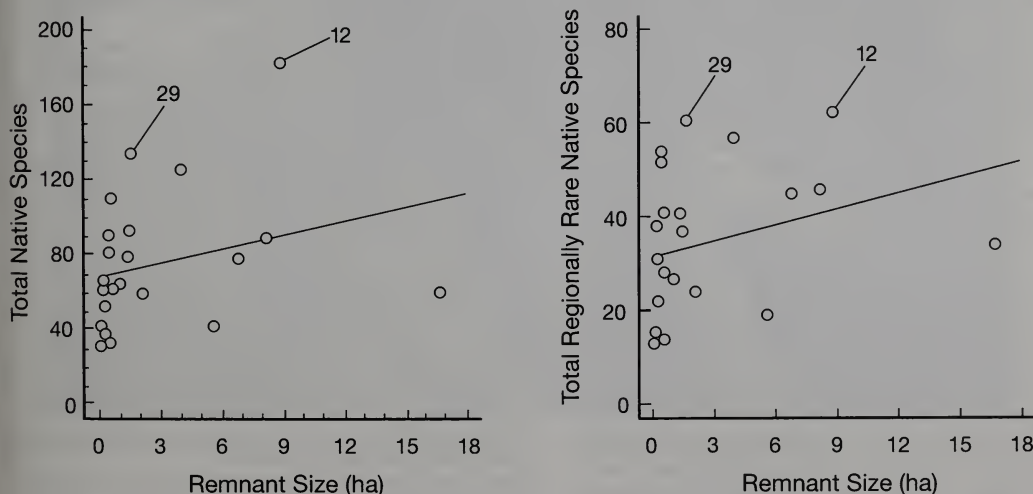


FIGURE 1. Trend lines based on simple linear regression for native species (left) and regionally rare native species (right). Although larger sites have more species, the relationship is not significant in this analysis (the F ratios are 0.20 for the left and 0.17 for the right), and less than 9% ($R^2 = 7.3$ left and 8.5 right) of the variation in number of species is explained by remnant size.

reduced to remnants by 1885. Although there may be increases in abundance of native species within a site and in abandoned farmland adjacent to a relict site (Catling and King 2008), there is little evidence that rare native species have spread to any of these sites since they became isolated in a landscape dominated by aggressive aliens such as Smooth Brome Grass. Thus some of the smaller remnants of the Rice Lake Plains are rich and persistent. Despite their persistence, they are in many cases now being overwhelmed by increasingly problematic invasive species and management is necessary if the rare native species are to survive and/or increase in abundance (Catling and King 2008). Of course the threat of invasives is the same for big or small areas.

Some may say that we are still better off with the larger area for a variety of reasons – and that may be true; but actually to maximally protect plant biodiversity, we may get more with a number of smaller areas (for the same price). The more important question though is: how many sites do we need to protect? This of course depends on the objective. In the present case, if we make the objective the maximum protection of plant biodiversity, then it is not too difficult to get an answer. The richest site (12) includes only 62 of 111 regionally rare plant species – a little over half. This lead site is lacking many distinctive prairie species such as Prairie Smoke (*Geum triflorum*) and Early Buttercup (*Ranunculus fascicularis*) which are present in the much smaller site 29, which with 60 regionally rare species, has almost the same number. Protecting these two sites we still have only 77% of the regionally rare plants. Consecutively protecting sites with maximum biodiversity, we need 8 sites to get 90%. We might get 95% with 8 sites using an optimization procedure or 100% with 10 sites.

It should be no surprise that remnants vary. The original ecosystem probably varied in composition spatially due to variation in soil content, moisture, slope, exposure and random events such as fire. Remnants are different from each other, although they have a lot in common, like the parts of a jigsaw puzzle.

It may be said that we could introduce species to augment numbers at a site, but this does not always work because sites vary in environmental conditions. We know that conditions are suitable where the plant is growing, but at another site they may not be, so transplanting to augment biodiversity does not always work if the objective is a functioning ecosystem rather than a garden. For more on transplanting see Fahselt (1988), Allen (1994), Schemske et al. (1994), Sperry (1994), Pavlick (1996), and Hubbard et al. (2001).

So we need about 10 well-chosen remnants to protect the regionally rare flora (and more would be better since we have not taken abundance of species into

account), but plants are not the only thing. Consider, for example, rare insects with a physical requirement for open sand, or the need for temporary pools to support toads (*Anaxyrus [Buto]*) which in turn support Hognose Snakes (*Heterodon*). Soon the number of isolated remnants required to adequately protect the vestiges of the biodiversity of the Rice Lake Plains is dozens, and this is true for many other landscapes as well.

The data on Rice Lake Plains remnants suggest that small sites are worth considering for protection and that many sites may be required to protect the remaining biodiversity. Large areas are desirable but conservation actions should be clever and opportunistic as well as idealistic. These ideas may be news to many people who think that one big example is enough, but fortunately this is not news to the Nature Conservancy of Canada. Over the last decade NCC has played a major role in protecting what is left of the Rice Lake Plains.

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A Tribute to Robert Hainault, 1940 – 2008

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Catling, Paul, Gisèle Mitrow, and Jacques Coyouette. 2008. A tribute to Robert Hainault, 1940-2008. *Canadian Field-Naturalist* 122(1): 95-98



FIGURE 1. Robert Hainault 1980 or 1981 during a botanical survey of Cathedral Park, British Columbia. Photographer unknown.

Robert Hainault passed away on 11 June 2008 at age 68 in Brockville General Hospital following a lengthy illness. Robert is well known as one of a group of several students and associates of the distinguished Dr. Roland Ernst Beschel (1928-1971) of Queen's University, an unusually influential field biologist and

conservationist (Andrews et al. 1971; Macpherson 1971; Smallman et al. 1991). Beschel was himself a student of Dr. H. Gams, a distinguished member of the Zurich-Montpelier school of plant ecology who specialized in mosses and lichens and wrote *Kryptogamenflora von Mitteleuropa*. The group that formed

around Beschel was composed of university students, high school students, and retirees. They formed a functional unit reflecting Beschel's research interests and funding, with A. E. Garwood in charge of the finances. In addition to Hainault and Garwood, the group included S. P. Vander Kloet, P. Little, I. D. MacDonald, C. H. Zavitz, D. Cuddy, D. Webb, P. Webber, R. Norman and others. Many of this group were extraordinary field botanists and went on to play an important role in field biology, teaching and conservation planning across Canada. Robert Hainault is a fine example. He became influential as a teacher and a collector of specimens that can now be found in museums around the world. His distinguished academic ancestry is reflected in his paper on the geon concept (Hainault and Beschel 1968), which represents the Zurich-Montelier interpretation of plant communities.

Robert was born on 25 January 1940 in Marieville, just outside Montreal. As a young boy, sitting on the porch, he was fond of watching Montreal light up in the evening. It was in 1947 that Robert met Frère Roger Laurent (Figure 2), who was a student of the great Quebec botanist, Frère Marie-Victorin. Laurent would not answer Robert's question about a plant unless the correct Latin name was used. To the end of his life Robert Hainault was distressed by forgetting a Latin name. Thus, to some degree Robert was a product of the tradition in Quebec of Catholic priests and brothers teaching biological taxonomy and respect for nature in children's camps and various kinds of schools.

When he was 11 the family moved to Hawkesbury on the Ottawa River, Ontario. Here he met Mr. J. Ephrem Charlebois (1900-1993), a cobbler in nearby Montebello on the Quebec side of the river. Charlebois was an avid field botanist, always making botanical discoveries and corresponding and exchanging plant material with many of the influential botanists of the period, including Brother Rolland-Germain, S. J. Hay, H. Goutier at Montreal, R. Cayouette at Quebec City, S. Brisson at Sherbrooke, and W. G. Dore, B. Boivin and J. Cayouette at Ottawa. His herbarium went to Sherbrooke and is now at QFA. Charlebois was in a position to teach a young student a great deal. Robert first met him as a leader of the local Boy Scout group. He frequently hitched a ride to Montebello so that they could collect plants together. Robert soon became an accomplished botanist and he wrote an article about his collections and observations at Montebello in 1958 (Hainault 1959). During this period, Robert could not afford a copy of *Flore Laurentienne* but he could afford the beetle identification leaflets (later published together in Chagnon and Robert 1962) which were 25 cents each so he collected insects as well as plants. Without appropriate mounting and storage these collections were lost but nevertheless paved the way for a later important contribution to entomology.

In 1959-1960 Robert was in grade 13 at the Hawkesbury District High School. He had an exceptional science and biology teacher, Lionel Parisien. Mr. Parisien had heard rumors that Professor Beschel at Queen's University was looking for some students so he kindly drove Robert from Hawkesbury to Kingston to meet Beschel and discuss the possibilities of him continuing his education at Queen's with Beschel's help. This was a major step in Robert's life and career. Although he completed his university education (B.Sc.) at The University of Ottawa from 1961 to 1966, his association with Dr. Beschel continued.

During the summer of 1962 he worked with the Fisheries Research Board on Victoria Island in the western Canadian Arctic and collected plants there that were identified with Beschel's help. In the 1960s, Beschel sent Robert out to collect plants in the countryside around Kingston. He completed his field work on the flora of the eastern Lake Ontario islands during the summers of 1963 and 1964. At that time fishing boats were operating from Prince Edward Point and they took him out to the islands and picked him up. During his field trips he often pulled out a copy of Voltaire's *Dictionnaire Philosophique*. He later read everything available by and about Voltaire and he regularly visited the sculpture (a statue) of Voltaire by Jean-Antoine Houdon on display in the European Room at the National Gallery of Canada.

In 1965 Robert collected plants on Baffin Island at Inugsuin Fiord (a foiled attempt to use a native word since "Inugsuin" means "fiord" in Inuit) as part of a cooperative study done by Queen's University and the Geographic Survey of Canada. A highlight of this trip was when a disgruntled RCMP officer pulled out a large manual and revealed a paragraph that indicated that a permit was necessary to collect plants in the Canadian Arctic. There was to be either a fine or a few weeks in jail. Robert contacted Garwood at Queen's University. He was advised by Garwood to take the jail term because the university had no extra funds. However, he was forgiven by the justice of the peace and resumed his collecting and cataloguing. Information from Robert's reports was used by other researchers studying arctic flora such as Rannie's (1986) study relating vascular plant diversity in the Arctic to summer air temperature and that of Beschel (1969) analysing arctic phytogeography.

In 1966 he returned to Queen's to begin working on his M.Sc. thesis project, "Flora of the islands of eastern Lake Ontario." He received the degree in 1969 and completed training as a teacher at McArthur College in 1970. From 1966 to 1968, Robert collected plants and documented flora in sites identified as significant as part of the International Biological Program (IBP). This was one of the first really important steps in identifying significant biodiversity on a very broad scale: its success depended on greatly skilled field biologists like Robert. During this period he col-

lected plants in many areas around Kingston, particularly in Frontenac Park. This documentation contributed much to the protection of valuable biodiversity in the region.

The early 1970s saw Robert in Cathedral Park on the southern border of British Columbia. Here he spent several summers studying the flora and collecting plants. He made many discoveries that improved the general knowledge of plant geography. He also collected on the way (from Ottawa) to and from the park in places such as the Cypress Hills.

From 1970 to 1985 Robert taught high school biology and chemistry in east Ottawa first in Vanier at André Laurendeau and later at Belcourt. He also taught biology at night school. With enthusiasm and a special sense of humour he was very popular with his students, and some of them went on to become biologists. He influenced over 2000 students, providing more extensive information on biology than was available to most high school teachers at the time and advocating conservation. During this period he donated plant specimens to the Agriculture Canada and National Museum collections. During the summer of 1979 he worked with J. H. Soper at the National Museum doing several thousand plant identifications. He was encouraged and assisted by legendary Canadian botanists Bill Dore and Bernard Boivin at the Department of Agriculture herbarium (DAO), as were many younger botanists of that time.

While at Belcourt Robert met fellow teacher Patricia Harvey. A few years later they married. In 1985 they bought an old house in the country near Addison, north of Brockville, Ontario, where Robert lived until his death. In 1999 Robert was hospitalized for a knee replacement. While in hospital he contracted an unusual strain of bacteria resistant to antibiotic and became disabled. This made plant collecting difficult so he returned to his youthful pursuit of entomology. Insects could be conveniently caught in light traps. Obtaining scientific monographs with the help of scientists he became an expert on various groups of beetles. He discovered several beetles that had not been found in Canada previously and collected material that helped with the classification of a number of groups. His collections numbering at least a few thousand are in the Agriculture and Agri-Food Canada Insect collection (acronym CNCI) in Ottawa.

In 1974 Hainault's personal collection numbered about 7000 plant specimens of which half were from the Kingston and Lake Ontario regions (Boivin 1980), but other regions mentioned above were also extensively represented. As part of the exchange program, DAO distributed duplicates to many herbaria, especially those in the prairie provinces and to the BC Provincial Museum. Beschel and subsequent workers at Queen's University distributed duplicates to herbaria worldwide, including particularly Russia and Canada (including TRT and QFA). In a 1967 report, Hainault's



FIGURE 2. J. Ephrem Charlebois, 1979 at Montebello, Quebec. Charlebois was instrumental in Robert Hainault's developing interest in botany. Photograph by Sam Brisson.

specimens at the Fowler Herbarium at Queen's University numbered 3000 (Beschel 1967) making him second to Beschel with regard to numbers of recent collections at the time. His collections were important in completing the checklist of the vascular plants of the Kingston area (Beschel et al. 1970). For the most recent list of Kingston region plants see Crowder et al. (1996). His collections were the basis for his thesis on eastern Lake Ontario islands (Hainault 1968), a report on Baffin Island (Hainault 1966a), and another concerning the flora of Montebello (Hainault 1959). In October 2007, his personal collection (numbering about 10 000 specimens at the time) was donated to National Plant Collection of Agriculture Canada (DAO) in Ottawa. Although mostly from the Kingston region, this collection also included specimens from British Columbia, Alberta, Saskatchewan, Ontario, Quebec, Labrador, New Brunswick, Greenland, Victoria Island and Baffin Island. The arctic and eastern Lake Ontario material is duplicated at Queen's University Herbarium (QK), but his prairie provinces and western material is best represented at DAO. There were 550 specimens of mosses which were transferred to the Canadian Museum of Nature (these being mostly from Baffin Island, Ontario, and British Columbia).

All aspects of nature inspired Robert Hainault. He collected many books and gave them away to friends and colleagues. He also developed a very large collection of botanical photographs which he shared. His donated collections of over 10 000 plant specimens (not including duplicates) as well as insects and mosses is a substantial contribution and his influence as a

very effective teacher and colleague is an equally substantial achievement. No less impressive is the way in which he, with the help of his wife, Patricia Harvey, overcame a debilitating disease that has left him without the ability to walk or write, yet he continued to contribute as a field biologist.

Acknowledgment

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Received 20 November 2007

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Book Reviews

ZOOLOGY: Animal Life — HBW IBC — Frog — Rattlers, Peepers & Snappers	83
BOTANY: Aromatic Plants in China — Aweto in China — Chinese Wild Orchids — The Vascular Plants and Their Eco-Geographical Distribution in the Qinghai-Tibet Plateau Area	85
ENVIRONMENT : A Primer of Conservation Biology	89
NEW TITLES	89

News and Comment

Michael Cheney 1956-2007 — <i>Marine Turtle Newsletter</i> (119) — The Library of the Swiss Orchid Foundation at the Herbarium	JANY RENZ	90
Small remnants of the Rice Lake Plains prove important ... how many do we need?	PAUL M. CATLING	93
A tribute to Robert Hainault, 1940-2008	PAUL CATLING, GISELE MITROW, and JACQUES CAYOUE	95

Mailing date of the previous issue 121(4): 20 March 2009

Articles

The extent and floristic composition of the Rice Lake Plains based on remnants

PAUL M. CATLING

Eye colour, aging, and decoy trap bias in Lesser Scaup, *Aythya affinis*

MARIE FAST, ROBERT G. CLARK, RODNEY W. BROOK, PETER L. F. FAST,
JEAN-MICHEL DEVINK, STEVE W. LEACH

Nesting biology of Lesser Canada Geese, *Branta canadensis parvipes*, along the Tanana
River, Alaska

CRAIG R. ELY, JOHN M. PEARCE, and ROGER W. RUESS

Lesser Snow Geese, *Chen caerulescens caerulescens*, and Ross's Geese, *Chen rossii*, of Jenny
Lind Island, Nunavut

RICHARD H. KERBES, KATHERINE M. MEERES, JAMES E. HINES, and DAVID G. KAY

Repeatability of foraging tactics in young Brook Trout, *Salvelinus fontinalis*

PETER A. BIRO and MARK S. RIDGWAY

Use of winter dens by Porcupines, *Erethizon dorsatum*, in Wisconsin

MICHELLE SOMERS and RICHARD P. THIEL

Wolf, *Canis lupus*, den site selection in the Rocky Mountains

JON R. TRAPP, PAUL BEIER,

CURT MACK, DAVID R. PARSONS, and PAUL C. PAQUET

Distribution and history of naturalized Common Pear, *Pyrus communis*, in Ontario

PAUL M. CATLING and GISELE MITROW

Annual vs. multiple year home range sizes of individual Blanding's Turtles, *Emydoidea
blandingii*, in central Wisconsin

MATTHEW SCHULER and RICHARD P. THIEL

Notes

Why do North American Red Squirrel, *Tamiasciurus hudsonicus*, mothers relocate their young?

A predation-based hypothesis

TRICIA KERR and SEBASTIEN DESCAMPS

Evidence for higher soil temperatures and potassium promoting invasion of the Common Dandelion,

Taraxacum officinale, in Denali National Park and Preserve, Alaska

ROSEANN V. DENSMORE

Nocturnal behavior of the Common Loon, *Gavia immer*

JAMES D. PARUK

Swimming Eastern Chipmunks, *Tamias striatus*, and Hairy-tailed Mole, *Parascalops breweri*,

in Kawartha Highlands Provincial Park, Ontario

ROOT GORELICK and SUSAN M. BERTRAM

Gray Wolves, *Canis lupus*, killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*,

in Montana, Alberta, and Wyoming

MICHAEL D. JIMENEZ, VALPA J. ASHER, CARITA BERGMAN,

EDWARD E. BANGS, and SUSANNAH P. WOODROOF

Dytiscid beetle remains discovered in a pellet from a Great Gray Owl, *Strix nebulosa*

KEVIN C. R. KERR

A group defense incident involving juvenile Striped Skunks, *Mephitis mephitis*

JEFFERY T. WILCOX and BRENDAN N. LARSEN

(continued on inside back cover)

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COVER: Ant lion (*Mymeleon immutatus*) larvae (left) and ant traps created by the larvae (right). This is one of a number of insects dependent upon open sandy ground. Photo on left taken at Slack Road, south side of Ottawa, 5 May 2002, that on right taken at Portage Bay, Manitoulin Island on 23 July 2003. Photos by H. Goulet. See article by Catling et al. 98-127.

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Decline of Two Open Champlain Sea Dune Systems in Eastern Ontario and Their Characteristic and Restricted Plants and Insects

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Open sandy areas have existed for hundreds or thousands of years in eastern Ontario but they have declined to approximately 1% of their former extent over the last 60-70 years. The history and decline of this unusual habitat, and its consequences for protection of biodiversity, are explored through reference to historical documents and collections as well as current surveys using two exemplary sites: Slack Road south of Ottawa and Crystal Rock in Edwardsburgh Township north of Prescott. Planting trees to eliminate these open areas, before their biodiversity value was understood, is a primary cause of the decline, but cessation of fire, invasive species and urban development have also been contributing factors. The two exemplary areas have a very similar flora and fauna and collectively contain at least five provincially rare and 65 regionally rare species, many of which are dependent on dry, open, inland sand deposits not directly associated with rivers or lakes. Based on the present rate of decline, these sandy habitats, along with their specialized flora and fauna, may be gone in a decade or two. On the other hand, the biodiversity-rich remnants could serve as nuclei for the recolonization of a restored ecosystem.

Key Words: dunes, sand, conservation, protection, vascular plants, insects, eastern Ontario.

Dry, open sand (Figure 1) is a distinctive habitat for many unique plants and animals specially adapted to extremes of heat and drought. Among the distinctive insect fauna are moth larvae that burrow in the sand feeding on roots of sparse vegetation and emerging only at night, beetles that bury themselves in the sand during the day and forage at night, as well as hoppers and other beetles that bury themselves at night and forage during the day.

Dry open sand barrens, dry meadows and bracken grasslands occur throughout the Great Lakes region (e.g., Curtis 1959). These kinds of interior open sandy habitats, not directly associated with water, were once much more widespread in the Mixedwood Plains and Prairie ecozones of Canada (Hugenholtz and Wolfe 2005; Catling 2008) but may now be one of the most seriously threatened ecosystems in northern North America. Although climate warming will likely increase the extent of open sandhills, there may be a lag period and there is concern that deterioration may proceed before climate change reverses the trend (S. A. Wolfe personal communication; Wolfe and Thorpe 2005). One of the reasons for their loss is the decline of natural processes such as fire which leads to con-

tinual rejuvenation (e.g., Filion 1984), and without which they become overgrown with dense vegetation. However, fire may not be the only important factor in maintaining a landscape with open sand. Others may be frequent drought and drier climate conditions. Invasive alien plants such as Brome Grass (*Bromus inermis* Leyss.) and Scots Pine (*Pinus sylvestris* L.) that do well in dry conditions (Otfinowski et al. 2007; Catling and Carbyn 2004) may also play a role in eliminating open sand. Urban and agricultural development of the landscape has reduced open sandy area in some regions such as the Annapolis valley of Nova Scotia (Carbyn et al. 2006); however, a major factor in the decline of open sand in the Mixedwood Plains Ecozone of eastern Canada has been the lack of conservation action resulting from the fact that open sand and peripheral areas have not been recognized as an important and biodiversity-rich ecosystem worthy of preservation.

The decline of open sand in the prairie region (e.g., Hugenholtz and Wolfe 2005; Wolfe and Thorpe 2005) has been associated with endangerment of flora and fauna. Several species from these habitats have been recently listed under the Species at Risk Act. The endangered species include Ord's Kangaroo Rat (*Dip-*

Edwardsburgh Sand Hills in Edwardsburgh Township north of Prescott, including dunes scattered over a broad area but particularly at Crystal Rock (44.7845°N, 75.5049°W). To evaluate decline of the open sand and dry meadows at Slack Road and Crystal Rock, aerial photographs were obtained from the National Air Photo Library of Natural Resources Canada. Those for Crystal Rock were photo A5670-045 taken 25 August 1937 and A28056-242 taken 13 May 1994 and for Slack Road were HA72-030, 73-006, 007, 019, 032, taken 5 June 1925, and A31788-087, taken 12 May 1999.

Historical information concerning the character of the landscape in pre-settlement times was obtained from early survey records (Ontario Ministry of Natural Resources, Land Information Ontario, Crown Surveys), historical reports and publications, and interviews with local historians.

At both Crystal Rock and Slack Road, plants were collected and deposited in the National Collection of Vascular Plants maintained by Agriculture and Agri-Food Canada, Ottawa (acronym DAO). Insects were also collected by active searching and use of pitfall traps. Approximately 50 visits were made to Slack Road by H. Goulet and others during the 1980s and 1990s and, for two years, sampling for hymenopters was conducted on a weekly basis. Bruce's Pit was visited several times by P. M. Catling between 2000 and 2007, and P. M. Catling and B. Kostiuk made 10 visits to the Crystal Rock site in 2007. Information on past collections from the Slack Road region was obtained from Agriculture Canada's Canadian National Collection of Insects (CNCI). While the survey of vascular plants is considered relatively complete, that of insects is very incomplete and favours groups well known to the authors (butterflies and moths, beetles, grasshoppers) or for which experts were readily available to assist with identification (spiders, wasps, bees, flies). Notes on other organisms are incidental.

The status of plants and insects as well as other organisms was determined using the collections and articles listing rare and restricted taxa. Restriction refers to confinement to dry sandy habitats and is based on literature (e.g., Lindroth 1961 to 1969b; Layberry et al. 1982, etc.) personal observation and information from the Canadian National Collections (CNCI, DAO). Restricted species are actually a subset of regionally rare species, some of which may or may not be habitat-restricted. Regional rarity refers to eastern (east of 75.5°W) Ontario and is defined as known to occur in less than five locations (1 km apart) in the region. Provincial rarity status for plants is derived from the Ontario Rare Plant Atlas (Argus et al. 1982-1987). Scientific names preceded by one asterisk (*) indicate regionally rare and restricted species whereas names preceded by two asterisks (**) indicate provincially rare species.

The scientific and common names and authorities used for vascular plants are mostly those of Kartesz

and Meachum (1999) and are included in Appendix Table 1 with only the Latin names appearing in the text. Since most insect species lack common names, there is no separate appendix list and the authorities are included in the text. The sources of names of insects are indicated where appropriate.

Results

Origin of the Dunes

The Champlain Sea was a deep embayment of the Atlantic Ocean. It occupied a depression created by the continental glacier. From approximately 13000 to 10000 years ago it gradually receded due to isostatic rebound of previously ice-covered landscape (Parent and Occhietti 1988). After 10000 years ago it became the smaller freshwater Lake Lampsilis (Elson 1969) and receded to the present Ottawa and St. Lawrence Rivers. Sand dunes, sandy outwash and marine fossils were left to indicate its former area, which extended from west of Ottawa, south to Lake Champlain and east of Montreal (Kindle 1918; Terasmae 1959; Harrington 1971, 1981, 1988; Anderson 1988; Gadd 1988). The dunes were a consequence of the action of wind and water carrying sand left by the glacier into the sea by major rivers and streams cutting through the glacial deposits.

In Edwardsburgh Township from the north side of the town of Prescott to a point 15 km NNW (in Limerick Forest), winds blowing across the Champlain Sea off the ice sheet about 9000 years ago were dominant, the winds from the west being developed later and reduced by forest. The onshore winds from the east resulted in characteristic parabolic dunes growing from the shore westward into the conifer forest (Terasmae and Mott 1959; Filion 1987; David 1988). The highest crests of the dunes evidently return to forest very slowly after forest removal by fire. The parabolic shape of the dune crests was evident to Terasmae and Mott (1959) because the lower parts of the dune fields had become revegetated leaving the curved white dune crests clearly evident on an otherwise dark photograph. Although dune activity (movement) apparently ceased several thousand years before present (David 1988), the higher parts of the sandy deposits were probably prone to fire and drought and may have remained as open sand, sandy grassland and scrub for thousands of years as islands in a largely forested landscape. Supporting this view, Filion (1987) reported minor eolian erosion of Champlain Sea dunes at Rivière-du-Chêne, Quebec, as a result of wildfire 1250 years before present.

Recent History (pre-settlement to early or mid-1900s)

(1) Crystal Rock, Edwardsburgh Township

The Sand Hills of Edwardsburgh Township and part of Augusta Township north of Prescott are part of an extensive sandy area designated as Rubicon sand in the county soil survey (Richards et al. 1949; Figure 2) that may have been more or less open (unforested)

for thousands of years. This could have been a consequence of both natural fires and fires set to improve hunting by native peoples, including the Paleo Indians followed by the Archaic cultures, both hunters and gatherers. However, a far more significant trend in opening the landscape was the establishment of the Woodland culture, which began after 1000 B.C. during which time the hunters and gatherers were replaced by the agricultural and well-organized Iroquois. At least six major Iroquoian villages have been documented in the Sand Hills area (Pendergast 1966), the first of which was reported in 1854 (see Leavitt 1972), including the multi-pallisaded Roebuck site (Wintemburg 1936). Agriculture was well developed at this and the other sites. It included corn, beans, sunflowers, tobacco, and squash (Wintemburg 1936). Three to six square miles of cultivated land surrounded the villages of at least one to two thousand inhabitants and beyond that were areas where wood was collected for cooking, heating, and construction of longhouses and repair of 30-foot high pallisades. The open land created around villages would probably be in the order of hundreds of km² (J. V. White, personal communication). Exhaustion of supplies of firewood was a primary reason for the abandonment of Iroquoian villages (J. V. Wright, personal communication). Consequently, villages like the Roebuck site moved from place to place over periods of several decades undoubtedly creating extensive treeless areas in various stages and rates of succession back to forest. The impact of the Iroquois may have lasted until 1500 A.D. They had disappeared from the region by 1535 when Jacques Cartier arrived (Pendergast 1995).

In Grenville County, without exception, the Iroquoian villages were located on the sandy deposits of the Champlain Sea, and the Crystal Rock dunes were the site of a well-known pre-Columbian village (Pendergast 1962). Charred corn and pipes were abundant at the site, suggesting the cultivation of at least corn and tobacco. Although there was evidence for at least three longhouses, there is a possibility that the Crystal Rock village was a smaller, periodically occupied, farm village associated with one of the major villages (Pendergast 1962).

Although aboriginal activity may have opened up sandy areas and maintained open sandy areas, the rates of vegetation succession and lack of sufficient effective wind may have prevented any significant dune activity, as occurred elsewhere in Canada (Wolfe et al. 2007). This may explain the fact that the primary active dune pattern on the landscape dates back to the Champlain Sea.

It is probable that the pine forests found in the Sand Hills region noted by the first settlers in early 1800s (Cameron 1994) developed gradually on mesic and drier sand after departure of the Iroquois. In the early 1800s these forests were probably at least 100 years old (large enough to provide masts for ships) and

their presence indicates open areas around 1700. Extensive pine stands called "pineries" were characteristic of previously open sites because the young pines favour open areas with exposed mineral soil for establishment. The pineries often developed on the landscapes previously occupied by native people (Day 1953). These pineries were also prone to fire, which burned in a mosaic leaving a patchwork of openings. Mohawks and fur traders moved into the area during the 1700s and there was likely at least some of the traditional burning to improve hunting (Day 1953) which likely also contributed to the perpetuation of openings during this brief period of decreased human impact. The St. Lawrence River was a highway to the wilderness of the Great Lakes from 1684 to 1720, at which time Johnstown (then called La Galette) was one of a number of trading posts around which open areas were maintained by tree cutting.

The removal of woody vegetation began on a grand scale during the European settlement period of the 1800s, but not only for heating, cooking and construction. The large pines were cut along the "Mast Road" north of Johnstown to provide masts and wood for ship building (Newman 1967 and personal communication). Subsequently, cordwood was cut for the many steam-powered boats operating along the major transportation route of the St. Lawrence River. Throughout the Sand Hills region, but especially around Crystal Rock, wood was also cut for burning limestone in pits and later in kilns to produce lime. Illustrations of the open dunes are included in some of the historical documents (Cameron 1994; Woodhead 1995). The subsistence agriculture of the late 1800s and early 1900s utilized the landscape almost completely for a variety of crops, but in the sand hills region especially for rye to supply the distillery in Prescott. Livestock was prevalent, including horses, dairy cattle, sheep and pigs (Newman 1967; Edwardsburgh Centennial Committee 1967). The intensive agricultural use of the landscape destroyed most of the natural habitat but some of the sand areas may have been spared due to extreme dryness and drifting sand making them unsuitable for most kinds of agriculture. Attempted agriculture in some dry areas resulted in wind erosion and loss of soil. The drifting sand and any sandy ground were regarded as a landscape damaged by poor agricultural practices rather than as a special ecosystem. In the 1920s and 1940s there were extensive areas of open sand as well as areas of sparse shrub and grassland (Woodhead 1995, page 2; Cameron 1994, page 5; Figure 3).

(2) *Slack Road, Ottawa-Carleton*

Although the Slack Road area of Ottawa-Carleton was beyond the northern limit of extensive Iroquoian settlements, there is evidence that it was used historically by native people who required wood and game and thus would have reduced forest cover. Artifacts have been found in the area (Jameson 1989*) and in adjacent areas along the Rideau River where it cuts

through sand deposits. The area is recognized for its archaeological resource potential (Laliberté 1998*), although evidence of extensive and continuous settlement is lacking.

The survey of McDonell and McDonald (1820*) of the first concession of Gloucester Township (now in the regional Municipality of Ottawa-Carleton but then Carleton County) recorded trees in 21 of 26 lots with a total of 75 tree records involving 14 tree species and 3.57 species recorded per lot. Pine was recorded in only five of the 21 lots and of these, three of the five records were from the adjacent lots 5, 6 and 7 corresponding to the Slack Road sand deposits. Elsewhere along the concession survey line hemlock, maple, basswood, ash and Yellow Birch were frequent. Clearly the three adjacent lots were anomalous and the presence of pine and birch (Lot 5) suggests early succession on sandy soils (since pine often germinates only on mineral soil in open conditions). This compared with climax forest suggested by the presence of hemlock, maple and Yellow Birch elsewhere. Consequently the reports of the first surveyor suggest that the Slack Road area had been open and sandy during the late 1700s and prior to the arrival of the first European settlers in the region (Philomen Wright's settlement in 1800 on the north side of the Grand (Ottawa) River at what later became Hull).

Similarly for the area of Bruce's Pit in the same sandy deposits 5 km to the west of the Slack Road remnants, Landon's (1824*) survey of Nepean Township indicated "pine land" on four contiguous lots on the line between Concessions 2 and 3, and the only "pine land" in 35 lots between Concessions 1 and 2 was in Lot 33. Thus there seems to be little doubt that the sandy deposits on the south side of Ottawa had been open prior to European settlement.

(3) General Observations

Considering the preceding historical information, the sandy ground in both the Slack Road and Crystal Rock regions may have been unforested with open sand and dry meadow for thousands of years as a consequence of drought and natural fire. This is supported by: (1) observations of pines and pineries by the first land surveyors and the earliest settlers; (2) the observation that in some of the drier sites today the invading cedars and poplars have died so that the driest openings can persist for long periods which is also supported by the open parabolic dune crests evident in aerial photographs taken in the 1950s; (3) a long history of open sandy habitats (for Edwardsburgh) in connection with Iroquoian agriculture; and (4) post-settlement wood harvesting for a variety of purposes that would have maintained the open habitats until several decades ago when wood declined in importance.

It has been suggested that the dunes in eastern Ontario became active only during post-European settlement times because of the absence of buried soil horizons (e.g., Johnson quoted in Porsild 1941) but this is



FIGURE 3. Drifting Sand Ridge photographed in 1920 between Crystal Rock and Prescott (Lot 30, Concession 1, Edwardsburgh Township, Grenville County, Ontario). Courtesy of the Canadian Geological Survey. Photo 48125 by J. Keele.

contrary to Filion's (1987) observation and the subject has not been studied extensively. Regardless, open sandy areas can exist without dune activity.

DOCUMENTATION OF RECENT HABITAT DECLINE

(1) Tree planting

The open sandy habitats throughout eastern Ontario declined for a number of reasons, but planting with both native and introduced pines played an important role everywhere, and in some places such as the Constance Bay Sand Hills, it is the major cause of habitat loss (White 1979; Wilson 1984). For decades in the past, open sandy areas were considered to be a very serious problem of soil erosion and such areas were subject to reduced property values. Tree planting was recommended for all open sandy areas to prevent erosion, redevelop soil cover and create value in terms of harvestable timber (e.g., Richards et al. 1949). The provincial government provided young established trees that could survive the dry conditions whereas their earlier seedling stage in nature could not. The strong reliance on wood in earlier times made this seem an appropriate use of the landscape. Biodiversity and its association with successional habitats were poorly understood during this period. Since open conditions may have persisted for many hundreds or thousands of years, tree planting was not necessarily restoring original conditions, although this was assumed to be the case at the time. Pines were planted in every open place that did not produce much hay or was unsuitable for crops. Later the densely planted trees became a dense monoculture with rich organic duff leading to a low-diversity forested community altogether unlike the open sand. Many areas that were not planted were rapidly invaded by ecosystem, altering invasive alien species such as Smooth Brome (*Bromus inermis*) and Scots Pine (*Pinus sylvestris*).

(2) Edwardsburgh Township and Crystal Rock Sand Dunes

The Crystal Rock dunes (Figure 4) were but one of several extensive open sandy dune areas that existed in Edwardsburgh Township 100 years ago. Even 50 years ago, many of these sandy areas were still present,



FIGURE 4. Aerial photographs of the Crystal Rock sand dunes (centre of photo at 44.7845°N , 75.5049°W). Left, photographed on 25 August 1937 (photo number A5670-045). Right, photographed on 13 May 1994 (photo number A28056-242). National Air Photo Library of Natural Resources Canada.

according to local inhabitants, and extensive sand at Crystal Rock is seen in early photographs such as Figure 3 (also reproduced in Woodhead (1995)), and the ca. 1950 oblique aerial view in Pendergast (1962). The open sandy areas of Edwardsburgh Township persisted for a few decades after 1940, but woody cover increased for three reasons: (1) fire was no longer a natural process on the landscape; (2) the need for wood declined as electricity became available for heating in the 1940s and 1950s and coal oil and propane also replaced wood for heating and cooking resulting in reduced tree cutting; and (3) much of the area was planted with pine and spruce during and after the 1930s and the well-established saplings were able to cope with the drought so that plantations developed rapidly. Invasive alien species capable of growth in dry places such as Smooth Brome, Flat-stem Blue Grass (*Poa compressa*) and Scots Pine became established in many of the open areas. By 2000 only a few very compromised patches of native sandy habitat remained (e.g., Figure 1). The 1937 aerial photograph (Figure 4) shows 103 hectares of sand and dry meadow at Crystal Rock, whereas the corresponding 1994 aerial photograph shows less than 3.5 hectares and most of this is associated with a few sand quarries. Invasive alien Scots Pines have taken over much of the dune area. Much sand was removed for construction of Highway 416 that dissected the dune system. Natural succession also reduced the open areas.

The decline of open sand at Crystal Rock has been paralleled by a similar, or even greater, decline in open sandy areas that existed previously throughout the townships of Edwardsburgh and Augusta. For example, the open dune crests in the photo published by Terasmae and Mott (1959), approximately centred on 44.8462°N , 75.6383°W , are now closed in (personal observation, August 2007).

3. Slack Road Sand Dunes

The Slack Road dunes (Figure 5) were one of a number of extensive open sandy areas extending in a broad east-west band about 3 km in length crossing the Rideau River at Uplands and Merivale on the south side of Ottawa. The extensive open sandy areas were used for pasture, leading to increased erosion, or they were quarried or developed into housing and industrial parks. Those not developed were planted with conifers or gradually grew in with invasive Scots Pines, buckthorn and native woody plants. Up until the 1980s the sandy areas at Slack Road, which is part of the Pinhey Forest Reserve (National Capital Commission), were considered to be abandoned agricultural land rather than remnants of former open and semi-open natural habitats (e.g., Mosquin and Gillet 1984*). Fortunately Mosquin and Gillet (1984*, p. 51) did recommend that the remaining open sandy areas not be planted in trees.

The once extensive sandy areas at Uplands are essentially gone, leaving only remnants at Slack Road

and Bruce's Pit, these being a fraction of a percentage of what was once present. An aerial photo of the Slack Road section in 1937 (Figure 5) shows 24 hectares of open sand reduced to 0.67 hectares by 1999. The open sand and associated dry meadow included 64.7 hectares in 1937 but it is now less than 1 hectare (Figure 5 and personal observation, 2007). The Slack Road system (Figure 5) was replaced by housing (upper left), pine plantations (right centre), and succession to forest, including invasive species (throughout the remainder).

FLORA AND FAUNA

The flora (see Appendix Table 1 for common names and authorities)

(1) General Vegetation

A number of very similar natural plant associations were present at both Slack Road and Crystal Rock. The surface ranged from open sand to mostly sand with scattered vegetation to half sand and half vegetation cover to a dense covering of vegetation so that the sandy substrate was not visible. The following description is based on vegetation at some of the least disturbed sites and those with the least number of invasive alien species.

Sparse vegetation on open sand includes *Cyperus houghtonii* (Figure 6) and/or *Sporobolus cryptandrus* and/or *Carex houghtoniana* and/or *Carex siccata*. *Polygonella articulata* (possibly recently introduced) occurs at Slack Road. In more stabilized sand the dominant vegetation is *Danthonia spicata* and *Pteridium aquilinum* sometimes with extensive lichen mats and *Polytrichum* moss, often referred to as Bracken Grasslands (e.g., Curtis 1959). Other characteristic species of this more climax association and the intermediate stages include *Anemone cylindrica*, *Calystegia spithamea*, *Carex cumulata*, *Carex merritt-fermaldii*, *Carex pensylvanica*, *Carex tonsa* var. *rugosperma*, *Carex tonsa* var. *tonsa*, *Dichanthelium depauperatum*, *Dichanthelium acuminatum* var. *fasciculatum*, *Diphasiastrum digitatum*, *Diphasiastrum tristachyum*, *Fragaria virginiana*, *Monarda fistulosa*, *Panicum virgatum*, *Phytalis heterophylla*, *Poa pratensis*, *Rubus allegheniensis*, *Rudbeckia hirta*, *Selaginella rupestris*, *Solidago juncea*, *Solidago nemoralis*, *Vitis riparia*, and other less frequent species (see Appendix Table 1).

The predominant shrubs present were *Prunus virginiana*, *Juniperus communis*, *Spiraea tomentosa*, *Amelanchier stolonifera*, *Amelanchier laevis*, and the surrounding trees included *Prunus pensylvanica*, *Pinus strobus*, *Pinus resinosa*, *Populus balsamifera*, *Populus tremuloides*, and *Thuja occidentalis*. In some remnants, *Picea glauca*, *Betula populifolia* and *Pinus banksiana* (just Slack Road region) surround sandy clearings.

Among the frequent introduced species *Hieracium piloselloides*, *Poa compressa* and *Silene vulgaris* are common on open sand; *Bromus inermis* occurs everywhere but dominates mesic sites. *Rumex acetosella* is frequent. *Pinus sylvestris* is frequent on edges and invades drier areas more successfully than native pines.

In Edwardsburgh Township, an area formerly owned by the Grand Trunk Railway west of Prescott, near Blue Church, is on the well-drained sandy soil. This entire area may have included sand barren vegetation at one time based on the relicts that exist around the pits formerly used to obtain substrate for railway construction and to provide water for steam engines. As a result of this use the area escaped the intense agricultural activity in the surrounding area, and parts of it evidently retained the original vegetation which was dominated by *Danthonia spicata* and *Carex siccata* with *Quercus rubra* and *Pinus strobus* (personal observation). A number of restricted species occurred here including *Ceanothus americanus*, *Cirsium discolor*, *Corylus americana*, *Desmodium canadense*, *Helianthus divaricatus*, *Helianthus strumosus*, *Lepedeza capitata*, *Lepedeza hirta*, *Maianthemum canadense*, *Monarda fistulosa*, and *Oryzopsis asperifolia* (Dore 1961 and personal observation). There is a possibility that some of these plants were introduced with railway ballast but the lack of extreme disjuncts and the usual railway flora (including the prairie grasses), and the occurrence of these species up to a kilometer from the tracks suggest that they are native.

The absence of any western prairie grasses (*Andropogon*, *Schizachyrium*, *Sorghastrum*) is interesting. It may in part be due to the sharp transition from very dry sandy blowouts to forest. Most places where these prairie grasses occur in the region are periodically damp due to spring flooding or brief rain retention by limestone rock. It is also of interest that a long-lasting scrub or heathland associated with a diverse flora, including many localized species such as existed on the Constance Bay Sand Hills on the Ottawa River northwest of Ottawa (Porsild 1941; Breitung 1957; White 1979), is not present on the Slack Road and Crystal Rock dunes. Both the extremes and high water table may have contributed to this situation resulting in open sand or forest without an intermediate long-lasting stage. Additionally intensive agriculture involving a variety of livestock could have reduced floristic diversity, since smaller subsistence farms in the early 1900s used even marginal landscapes very completely.

The most persistent sandy areas and those that remain today are the driest; these are the subject of this article. However, after fires there were also shorter-lived moist and mesic sandy habitats (personal observation). These would likely have supported the flora that is now most often associated with pond shores in sand pits and interdunal meadows on Great Lakes shores including such conspicuous plants as *Gentianopsis crinita* (Froel.) Ma (Greater Fringed Gentian), *Agalinis tenuifolia* (Vahl) Raf. (Slender-Leaf False Foxglove) and *Spiranthes cernua* (L.) Rich. (Nodding Ladies-tresses), along with *Equisetum variegatum* Schlecht. ex F. Weber and D.M.H. Mohr (Variegated Scouring-Rush) and *Danthonia spicata*, sometimes associated with more unusual and local species such as *Polygala sanguinea* L. (Purple Milkwort, particularly eastern

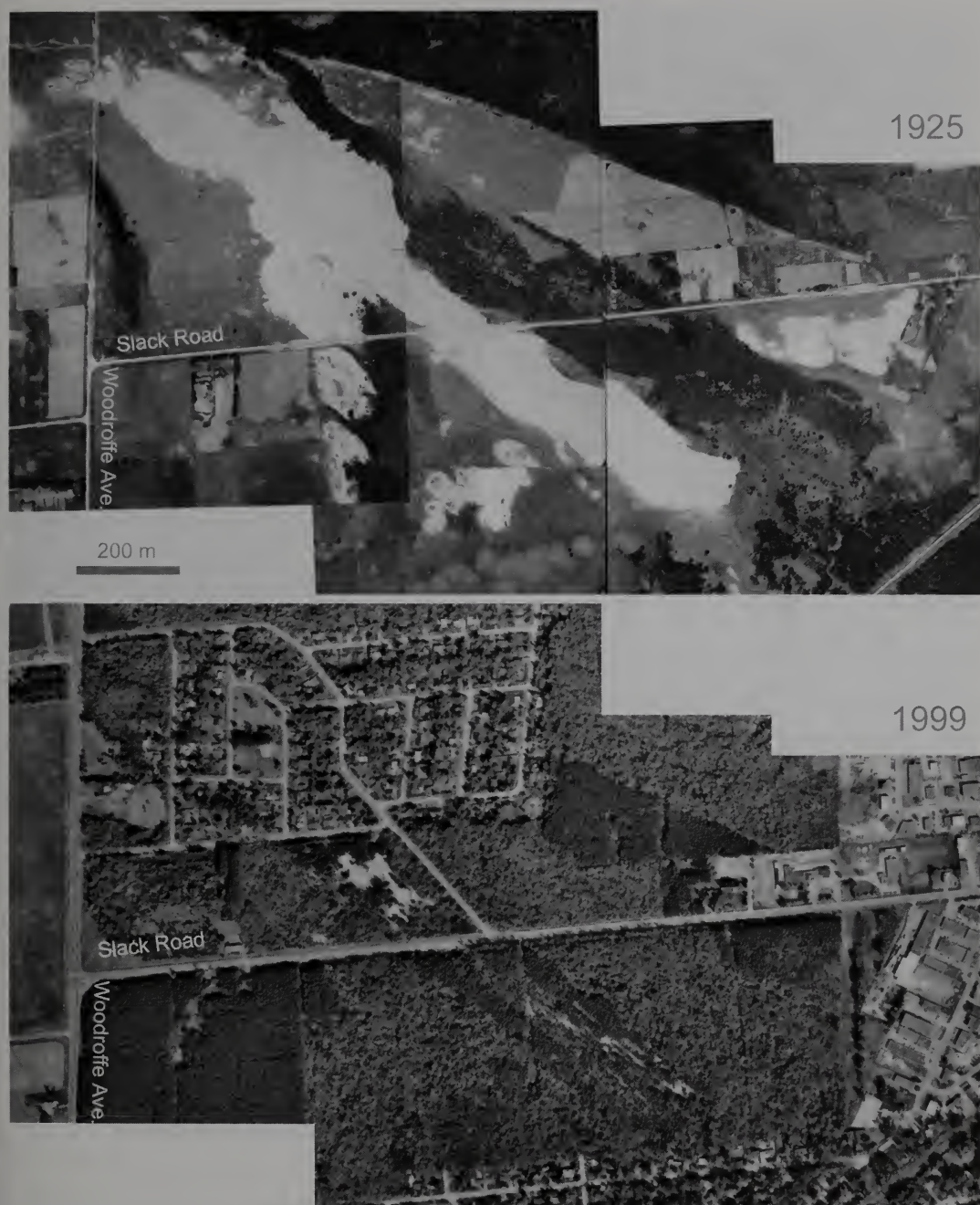


FIGURE 5. Aerial photographs of the sand dunes at Slack Road (centre of photo at 45.3215°N , 75.7325°W). Above, photographed on 5 June 1925 (photo numbers HA72-030, 73-006, 007, 019, 032). Below, photographed on 12 May 1999 (photo number A31788-087).



FIGURE 6. Inflorescence of the provincially rare Houghton's Flat Sedge (*Cyperus houghtonii*). Photo by B. Kostiuk from Crystal Rock, August 2007.

Ontario, see Reddoch 1972), **Polygala verticillata* L. (Whorled Milkwort), ***Juncus greenei* Oakes and Tuckerman (Greene's Rush) and *Drosera rotundifolia* L. (Round-Leaf Sundew). Prior to 1980, associations of this type were not unusual on bulldozed or burned sites on the sand plateaus east of Ottawa around Mer Bleue and near Casselman, but also occurred near Kemptville. These associations of mesic sandy sites may be relatively short-lived, possibly lasting for less than a few decades after initial disturbances. Introduced grasses such as *Phalaris arundinacea* and *Bromus inermis* may contribute to their short duration and general decline.

(2) Other plants and fungi

Sand barrens are rich in lichens in species of *Cladina* and *Cetraria*, but **Cladina rangiferina* predominates. It is widespread northward and in open places on the Canadian Shield but in eastern Ontario is confined to open sandy sites. The predominant mosses include several species of *Polytrichum* as well as *Tortula ruralis*. Some of these appear to be restricted but studies are incomplete. A number of fungi are associated with sandy, open sites. **Tulostoma* sp. (stalked puffballs)



FIGURE 7. The stalked puffballs (*Tulostoma* sp.) that grow in dry and open sandy places in the remnants of the Crystal Rock Sand Barrens are a complicated group of species, the classification of which is still unclear. Photo by P. M. Catling. The specimen illustrated is in the Agriculture and Agri-Food Canada Collection (Crystal Rock Barrens, 2007-05-12, P. M. Catling, DAOM (National Collection, Agriculture Canada, Ottawa)).

grow in dry and open sandy places at Crystal Rock Sand Barrens (Figure 7).

(3) Floristic significance

About 70 native vascular plant species exist in dry open areas of the Edwardsburgh and Slack Road sand hills (Appendix Table 1) and most of these (the characteristic species noted above) occur at both sites. There are two provincially rare plants present and 27 regionally rare plants, most of which are restricted to dry sand. In addition some of the mosses, lichens and fungi present are probably regionally rare.

Insects

(a) Butterflies and Moths

A number of butterflies are present as a result of abundance of their foodplants, including *Danaus plexippus* L. (Monarch), **Hesperia leonardus* Harris (Leonard's Skipper), **Callophrys niphon* (Hübner) (Eastern Pine Elfin), *Coenonympha tullia inornata* Müller (Inornate Ringlet). The young *Pinus strobus* around the remnant openings at Crystal Rock are one of the few places for *Callophrys niphon* in eastern Ontario where young pine groves have become scarce.



FIGURE 8. *Harpalus erraticus* (left) and *Cicindela lepida* (right). Both beetles are restricted in eastern Ontario to declining areas of open sand. Left photographed at Burnt Island, Manitoulin Island on 8 August 2003. Right photographed at Slack Road, south side of Ottawa, 9 September 2007. Photos by H. Goulet.

The most notable butterfly and one restricted to the dry sandy soils, often over limestone, in the region, is **Chlosyne gorgone* (Hübner) (Gorgone Checkerspot), the larvae of which feed on *Rudbeckia hirta* L. var. *pulcherrima* Farw. (Black-eyed-Susan). This foodplant is sometimes considered a recent introduction in Ontario, but in eastern Ontario it occurs in natural habitats with native species and likely occurred as a weed in Iroquoian fields along with cultivated sunflowers, which are also a larval foodplant of *M. gorgone*. The butterfly is currently known in Ontario only from the sandy areas of Edwardsburgh Township north to Kemptville and is disjunct from the far west (Catling and Layberry 1996, 1997, 1998). **Atrytone logan* W. H. Edwards ssp. *logan* (Delaware Skipper) is also present at some Edwardsburgh Township sites.

**Euxoa detera* and **Agrotus vestuta* are common moths in the western prairie region but local and confined to sandy soils in the east. The larvae of both species burrow in the sand in open sandy sites at Crystal Rock where they feed on the roots of a variety of plants. *Euxoa albipennis*, *E. scandens* and *E. quebecensis*, present at Crystal Rock, are also associated with sand but occur in less open sites.

(b) Beetles

Particularly notable at Crystal Rock were the carabid beetles, including **Anisodactylus merula* (Germar), **A. rusticus* (Say), **Harpalus erraticus* Say (Figure 8, left), **H. fuscipalpis* Sturm, **H. lewisii* LeConte, and **H. plenalus* Casey, all restricted to dry, open sand. The *Anisodactylus* species and *Harpalus erraticus* were particularly abundant with hundreds of each observed. The three tiger beetles **Cicindela formosa* *generosa* Dejean, **C. scutellaris lecontei* Haldeman, and **C. lepida* Dejean (Figure 8, right) are restricted to dry, open sandy habitats and are very localized in eastern Ontario (personal observation). *Cicindela tranquebarica* Herbst was also present at Slack Road. *Cicindela lepida* (Figure 7), strongly associated with

fine, open sand with which it blends well, has a short midsummer flight season and is generally rare throughout its Canadian range. Recent observations have suggested that this species is declining (e.g., Stanton and Kurczewski 1999). Other carabid species characteristic of the sandy sites at Crystal Rock, but less restricted include *Amara quenseli* (Schönherr), *Cicindela punctulata punctulata* Oliver, *Harpalus compar* LeConte, *H. herbivagus* Say, and *H. opacipennis* (Haldeman). The large **Harpalus caliginosus* (Fabricius), although less restricted to open sand in the southern parts of its range, is rare at its northern range limit in eastern Ontario.

(c) Grasshoppers and their relatives

**Spharagemon collaris* (Scudder) (Mottled Sand Grasshopper, Figure 9) was common locally in the dry, open sandy areas dominated by the graminoid plants *Sporobolus cryptandrus* and *Cyperus houghtonii* in both regions. It often persists in isolated pockets of open sand less than $\frac{1}{10}$ the size of a Canadian football field (approx. 596 m²). It is a species restricted to dry, open sand. Also restricted, but tolerant of less open sand **Spharagemon bolli bolli* Scudder (Boll's Grasshopper) was present in both areas. **Melanoplus keeleri luridus* (Dodge) (Keeler's Grasshopper), associated with dry habitats, and **Melanoplus punctulatus punctulatus* (Scudder) (Pinetree Spurthroat Grasshopper), an arboreal species associated with *Pinus strobus* are also noteworthy. A characteristic species of dry, open woodland, **Chloeaaltis conspersa* Harris (Sprinkled Broad-winged Grasshopper) was common in dry *Danthonia spicata* grasslands. The widespread *Melanoplus sanguinipes sanguinipes* (Fabricius) (Migratory Grasshopper) was very abundant. Other grasshoppers less common in the area included widespread species: *Disosteira carolina* (Linnaeus) (Carolina Grasshopper), *Melanoplus femurrubrum* (DeGeer) (Redlegged Grasshopper), and *Chortophaga viridifasciata* (De Geer) (Greenstriped Grasshopper).



FIGURE 9. One of the band-winged grasshoppers (pale yellow wings with a black border), *Spharagemon collare* (Mottled Sand Grasshopper) strongly resembles sand. Photographed early August 2007 at Crystal Rock by P. M. Catling. Specimen in CNCI (Canadian National Collection of Insects, Agriculture Canada, Ottawa).

The small cricket **Allonemobius griseus griseus* was extremely abundant at Crystal Rock. This species is only found in dry, open sandy areas. The ubiquitous *Gryllus pennsylvanicus* (Common Cicket) was also abundant. *Oecanthus quadripunctatus* Beutenmüller (Fourspotted Tree Cricket) was frequent on *Rubus allegheniensis* and *Oecanthus fultoni* T. J. Walker (Snowy Tree Cricket) was also present.

(d) Wasps and Bees

At Crystal Rock the most notable sand inhabitant was the spheciform wasp **Microbembix monodonta* (Say), a scavenging wasp which excavates nesting and sleeping burrows in loose colonies in areas of open sand (Figure 10). Two much larger, related species of *Bembix*, **B. americana spinolae* Lepeletier and **B. pallidipicta* F. Smith, also sand burrowers, have been collected at the sites under study, but the latter only at Edwardsburgh. Three species of *Ammophila* that are likely more or less restricted to areas with open

sand have been collected at both sites: *A. kennedyi* (Murry), *A. harti* (Fernald) and *A. urnaria* (Menke).

Among the newly reported (for Ontario) spheciform wasps that nest in sand and are known in the Ottawa area from the Merivale, Slack Road, Uplands and Bruce's Pit sand system are ***Diploplectron peglowi* Krombein, which is rare in the east, as well as **Miscophus americanus* Fox, and **Plenoculus davisii* Fox (Buck 2003). The biology of ***Cerceris nitidoides* Ferguson, collected in Ontario only at Slack Road, is unknown but related species nest in sand.

Small parasitic Hymenoptera in the family Scelionidae are mostly (95%) undescribed in North America. Two undescribed species in the *Trimorous ninus* group, parasitic on the eggs of the localized tiger beetles (*Cicindela* spp.) are known from Slack Road. An undescribed species of *Idris*, parasitic on spiders' eggs is known only from Slack Road and the state of Nebraska. Another undescribed species of *Idris* has never been found at Slack Road but is common at Crystal

Rock It is estimated that 20-25 species of undescribed scelionid wasps occur in the Slack Road and Crystal Rock sand areas (L. Masner, personal communication).

The bee **Colletes inaequalis* Cresson was excavated from burrows in the sand at Crystal Rock. It is one of approximately 50 bees in eastern Ontario that use loose open sandy areas to produce burrows containing brood cells (in this case lined with a waterproof, cellophane-like material that retards decomposition of stored nectar). Another bee at Crystal Rock, **Lasioglossum vierecki* (Crawford), is also dependent on open sand and has a restricted distribution in southern Ontario.

(e) Flies

Two flies of the family Therevidae occur on both the Slack Road and Crystal Rock sands: **Cyclotelus rufiventris* Loew and **Spiraverpa senax* Walker. Both are restricted to open areas where the larvae burrow through the sand preying on fossorial arthropods. A fly belonging to the Bombyliidae, **Exoprosopa fascipennis* (Say), that only parasitizes the sand burrowing *Bembex* wasps has been found at Slack Road. Several flies of the family Asilidae are strongly associated with sand and among these **Proctacanthus milberti* Macquart and **Cyrtopogon falto* Walker occur in both dune regions studied. Hundreds of other species of flies not restricted to sandy areas were also present.

(d) Spiders

The most abundant spider in pitfall traps at Crystal Rock was *Steotoda albomaculata* (DeGeer). This species (Figure 11) was not strongly associated with open sand but characteristic of very dry, open places where it occurred under bark, under the cover of sedge clumps and in lichen mats. Ten other species of spiders were recorded, including *Agelenopsis potteri* (Blackwall), *Castianeira longipalpa* (Hentz), *Gnaphosa parvula* Banks, *Phidippus purpuratus* Keyserling, *Schizocosa avida* (Walckenaer), *Schizocosa saltatrix* (Hentz), *Tibellus oblongus* (Walckenaer), *Trochosa terricola* Thorell, *Xysticus triguttatus* Keyserling and *Zelotes hentzi* Barrows. Some of these are likely restricted, but information on occurrence is incomplete.

(e) Other insects

The larvae of **Myrmeleon immaculatus* DeGeer (Ant Lions – Neuroptera) require open sand to develop pitfall ant traps and are consequently restricted to open, sandy sites (issue cover). These insects were found at Slack Road but have yet to be seen at other sandy areas of eastern Ontario. A number of ant species and representatives of several other insect groups present at the two sites may have been restricted to open sand, but occurrence data are presently insufficient to draw conclusions.

OTHER FLORA AND FAUNA

The small size of existing remnants is limiting to larger animal species, but ***Common Nighthawks* (*Chordeiles minor* (Forster)) nested on a larger rem-



FIGURE 10. A sphecid wasp, *Microbembix monodonta* (Say) at entrance to burrow in open sand. Photographed late August 2007 at Crystal Rock by P. M. Catling. Specimen in CNCI.

nant at Crystal Rock in the 1980s and **Clay-coloured Sparrows* (*Spizella pallida* (Swainson)) were present during the breeding season. Pine Warblers (*Dendroica pinus* A. Wilson) have been present in the pine stands at Crystal Rock and although pine stands are widespread in eastern Ontario today, young stands have become quite scarce. **Grasshopper Sparrows* (*Ammodramus savannarum* (Gmelin)) have been observed on the dry grasslands at Uplands.

The early reports of ***American Badgers* (*Taxidea taxus*), which are associated with sandy ground, at Crystal Rock seem unlikely since the easternmost reports are otherwise from southwestern Ontario. However, Cameron (1994) noted on the authority of the Newmans, who lived on the south side of the sand hills, that the badgers around Crystal Rock “were not only dangerous, but would attack other animals and steal chickens ... Badgers were nearly eradicated.” They recalled the bears (presumably **American Black Bears* (*Ursus americanus* Pallas)) and badgers in the early days which would have been ca. 1875 (T. Cameron, personal communication). Although badgers may disperse over 100 km within a year, eastern Ontario is at least 400 km east of the main range in southwestern Ontario (Lintack and Voigt 1983; Newhouse and Kinley 1999*) and the lack of material evidence makes the records doubtful.

Open sandy areas, where sufficiently extensive, are important habitats for reptiles. Even when greatly



FIGURE 11. The spider *Steotoda albomaculata* (DeGeer), abundant on dry and hot sandy ground, generally hiding under bark, lichen mats and under foliage. Photographed in late June 2007 by P.M. Catling at Crystal Rock. Specimen in CNCI.

reduced, they retain significance as nesting sites for turtles. The Crystal Rock sites have been used extensively by **Blanding's Turtles (*Emydoidea blandingii* (Holbrook)).

Decline of flora and fauna in sandy areas

Although there is little quantitative information on declines of plants and insects in Slack Road and Edwardsburgh Township sand deposits, the continuous trapping of parasitic wasps at Slack Road has strongly suggested a very substantial decline. During the 1980s the numbers of individuals and species declined by 50% and further decline has continued to the present. It is believed that these declines are a consequence of a variety of factors, including loss of habitat and spraying with pesticides, especially to control mosquitoes in adjacent pine plantations.

Several plant species appear to have been extirpated on the dry open sandy areas of Edwardsburgh Township; at least they are now extirpated in their only known locations. Included here are *Lespedeza capitata* and *L. hirta*. Several beetles and plants including *Monarda fistulosa* were eliminated when sandy areas at Uplands were replaced with urban development. Others including the Mottled Sand Grasshopper (*Sphaeragon collaris*) were extirpated when dry, open sand

grew in with invasive Glossy Buckthorn (*Frangula alnus*) and other woody vegetation.

Other sand dunes of the Champlain Sea

Other extensive dry areas occurred elsewhere on the borders of the Champlain Sea in New York state and southwestern Quebec and elsewhere in the lower Ottawa valley. It appears that all of these sites have in common (1) a similar dominant and restricted flora and fauna; (2) some species unique to the site; and (3) a substantial decline in areas of open sand and unforsaken area over the last 100 years. A few examples follow.

The only other area of sand associated with the Champlain Sea that is fairly well known in Ontario is the Constance Bay Sand Hills (Porsild 1941; Breitung 1957). Information on the decline of this biodiversity-rich site is available in White (1979 and Wilson (1984).

The Bourget Barrens west of Bourget and north of Casselman were planted with conifers or have grown in or became part of urban or agricultural developments. Vestiges of these sandy areas and others to the west, in vicinity of Mer Bleue and on the ridges in Mer Bleue (near 45.3938°N, 75.5092°W), existed until the 1990s. They were very similar to the Slack Road and Crystal Rock sites but had a higher water table

and were more prone to filling in with trees without fire. Natural succession and invasion of Glossy Buckthorn (*Frangula alnus*) have eliminated most of these habitats.

Rare species are documented at a number of sites on Champlain Sea sand deposits in Quebec. A few provincially and regionally rare plants occur in the shrinking sandy openings at Cazaville near Saint-Anicet (Boudreault and Brisson 1994; Barbeau and Brisson 2004*). Andre Castagnier, who grew up on the site of the sand barren at Saint-Anicet, southwest of Valleyfield in Quebec, noted that the open sandy area was far more extensive 50 years earlier. This area, very similar to Crystal Rock, has open sandy ground with scattered *Danthonia spicata*, *Rubus alleghaniensis*, *Carex tonsa* var. *rugosperma*, *Dichanthelium depauperatum*, *D. acuminatum* var. *fasciculatum* and *Pteridium aquilinum* but is best known for the relatively large population of *Monarda punctata* in the open sand (Barbeau and Brisson 2004*), this being the only site in Quebec. Also present are *Aristida basiramea* (see Allen 2002*), *Ambrosia psilostachya* and *Hedeoma hispida*. The open area is growing in with *Populus tremuloides*, *Acer rubrum*, and *Pinus strobus*, and introduced *Bromus inermis* and *Rumex acetosella* appear to be increasing on the site (personal observation). Barbeau and Brisson (2004*) thought it likely that natural fires maintained open sandy areas in the pine forests of the region. Of course this makes sense because the pine forests found in the region by the early settlers would have required open sand to develop.

Other naturally open or semi-open sandy areas in Quebec are mapped by Filion (1987) and David (1988) and noted by Larochelle (1975) in a list of sites where *Cicindela lepida* occurs which he searched for specifically and which is confined in Quebec to the region of the former Champlain Sea (including Lachute, St. Phillippe, Lanoraie, Pointe-du-Lac, Choisy, Como, Hudson, Rigaud, Ste-Marthe, and St. Lazare; more precise locations are provided by Larochelle (1975)). These areas occur on both sides of the St. Lawrence River and include sand deposits several km south of Rigaud. These sites are disappearing and have not been inventoried in depth but they include characteristic and restricted flora and insects such as the grasshopper *Psinidia fenestralis*, among others.

Conclusions

Open sandy areas that existed for hundreds or thousands of years in eastern Ontario have declined to approximately 1% of their former extent over the last 60 to 70 years due to tree planting, invasion of alien plants, destruction for urban developments and natural succession to woodland in the absence of fire. This is supported by both historical information and a persisting rich assemblage of rare and restricted species of open sand. The sandy areas dependent vascular plants and insects have declined not just due to habitat

loss but they also apparently have been influenced by invasive species and use of pesticides in adjacent areas. Although climate change may increase activity of shoreline dunes in southern Ontario (e.g., Wolfe and Nickling 1997), it is less likely to cause expansion of sandy areas in eastern Ontario inland dunes that have always probably been dependent on natural fire and other disturbances. At the Slack Road and Crystal Rock dune study sites, the regionally rare and restricted species include 29 vascular plants and 36 insects, most of these dependent upon dry, open sand habitats, but the numbers of restricted species are likely much higher because insects, lichens and mosses at these sites require much more study. The recent survey suggests that most of the restricted species still exist in these areas despite substantial loss of habitat and local extirpation. However, based on the present rate of decline, these and other sandy habitats in the Champlain Sea region, along with their specialized flora and fauna, may disappear within a few decades. On the other hand, the biodiversity-rich remnants could serve as nuclei for the recolonization of a restored ecosystem. Appropriate management would require cutting woody plants and removal of invasive species as well as bulldozing or other disturbance to expand and maintain open sandy areas for colonization.

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APPENDIX 1

List of plants occurring in open sandy area of the Slack Road region (SR) and/or the Crystal Rock and nearby sandy areas (CR) in Edwardsburgh township. ** = provincially rare in Ontario; * = regionally rare in eastern Ontario (east of Ottawa); + = introduced.

- Amelanchier arborea* (Michx. f.) Fern. var. *arborea*, Downy Service-Berry (CR,SR)
Amelanchier laevis Wieg., Allegheny Service-Berry (CR,SR)
Amelanchier stolonifera Wieg., Running Service-Berry (CR,SR)
Anaphalis margaritacea (L.) Benth., Pearly-Everlasting (CR,SR)
Anemone cylindrica Gray, Long-Head Thimbleweed (CR,SR)
Apocynum androsaemifolium L., Spreading Dogbane (CR,SR)
Asclepias syriaca L., Common Milkweed (CR,SR)
Betula papyrifera Marsh., Paper Birch (CR,SR)
Betula populifolia Marsh., Gray Birch (CR)
+ *Bromus inermis* Leyss., Smooth Brome (CR,SR)
* *Calystegia spithamea* (L.) Pursh ssp. *spithamea*, Low False Bindweed (CR,SR)
* *Carex cumulata* (Bailey) Fern., Clustered Sedge (CR,SR)
* *Carex houghtoniana* Torr. ex Dewey, Houghton's Sedge (CR,SR)
* *Carex merritt-fernaldii* Mackenzie, Merritt Fernald's Sedge (CR,SR)
Carex pensylvanica Lam., Pennsylvania Sedge (CR,SR)
* *Carex siccata* Dewey, Dry-Spike Sedge (CR,SR)
Carex tonsa (Fern.) Bickn. var. *rugosperma* (Mackenzie) Crins, Shaved Sedge (CR,SR)
* *Carex tonsa* (Fern.) Bickn. var. *tonsa*, Shaved Sedge (CR,SR)
* *Ceanothus americanus* L., New Jersey-Tea (CR)
Cirsium discolor (Muhl. ex Willd.) Spreng., Field Thistle (CR)
* *Corylus americana* Walt., American Hazelnut (CR)
Corylus cornuta Marsh. var. *cornuta*, Beaked Hazelnut (CR,SR)
** *Cyperus houghtonii* Torr., Houghton's Flat Sedge (CR,SR)
Danthonia spicata (L.) Beauv. ex Roemer and J.A. Schultes, Poverty Wild Oat Grass (CR,SR)
* *Desmodium canadense* (L.) DC., Showy Tick-Tefoil (CR,SR)
Dichanthelium acuminatum (Sw.) Gould and C.A. Clark var. *fasciculatum* (Torr.) Freckmann, Tapered Rosette Grass (CR,SR)
* *Dichanthelium depauperatum* (Muhl.) Gould, Starved Rosette Grass (CR,SR)
Diphasiastrum complanatum (L.) Holub, Northern Running-Pine (CR,SR)
Diphasiastrum digitatum (Dillenius ex A. Braun) Holub, Southern Running-Pine (CR,SR)
* *Diphasiastrum tristachyum* (Pursh) Holub, Blue Ground-Cedar (CR,SR)
Equisetum hyemale L., Tall Scouring-Rush (CR,SR)
Fragaria virginiana Duchesne ssp. *virginiana*, Virginia Strawberry (CR,SR)
+ *Frangula alnus* P. Mill., Glossy Buckthorn (SR)
Gaultheria procumbens L., Eastern Teaberry (CR,SR)
* *Helianthus strumosus* L., Pale-Leaf Woodland Sunflower (CR)
* *Helianthus divaricatus* L., Woodland Sunflower (CR)
+ *Hieracium piloselloides* Vill., Tall Hawkweed (CR,SR)
+ *Juniperus communis* L. var. *depressa* Pursh, Common Juniper (CR,SR)
* *Lespedeza capitata* Michx., Round-Head Bush-Clover (CR)
* *Lespedeza hirta* (L.) Hornem. ssp. *hirta*, Hairy Bush-Clover (CR)
Lycopodium clavatum L., Common Club-Moss (CR,SR)
Lycopodium dendroideum Michx., Prickly Tree Club-Moss (CR,SR)
* *Lycopodium lagopus* (Laestadius ex C. Hartman) G. Zinserling ex Kuzeneva-Prochorova, One-Cone Club-Moss (CR,SR)
Lycopodium obscurum L., Flat-branched Tree Club-Moss (CR,SR)
Maianthemum canadense Desf., False Lily-of-the-Valley (CR,SR)
Maianthemum stellatum (L.) Link, Starry False Solomon's-Seal (CR,SR)
* *Monarda fistulosa* L. ssp. *fistulosa*, Oswego-Tea (CR,SR)
Muhlenbergia mexicana (L.) Trin., Mexican Muhly (CR,SR)
Oryzopsis asperifolia Michx., White-Grain Mountain-Rice Grass (CR,SR)
* *Panicum virgatum* L., Wand Panic Grass (SR)
Physalis heterophylla Nees var. *heterophylla*, Clammy Ground-Cherry (CR,SR)
Picea glauca (Moench) Voss, White Spruce (CR,SR)
* *Pinus banksiana* Lamb., Jack Pine (SR)
* *Pinus resinosa* Ait., Red Pine (also planted) (CR,SR)
Pinus strobus L., Eastern White Pine (CR,SR)
+ *Pinus sylvestris* L., Scots Pine (CR,SR)
+ *Poa compressa* L., Flat-Stem Blue Grass (CR,SR)
Poa pratensis L., Kentucky Blue Grass (CR,SR)

APPENDIX 1 (continued)

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- ** *Polygonella articulata* (L.) Meisn., Coastal Jointweed (possibly introduced in the Merivale area based on late collections) (SR)
Populus balsamifera L. ssp. *balsamifera*, Balsam Poplar (CR,SR)
Populus tremuloides Mich., Trembling Aspen (CR,SR)
- * *Potentilla arguta* Pursh ssp. *arguta*, Tall Cinquefoil (CR,SR)
Prunus pensylvanica L. f., Fire Cherry (CR,SR)
Prunus virginiana L., Choke Cherry (CR,SR)
Pseudognaphalium obtusifolium (L.) Hilliard and Burt., Blunt-leaf Rabbit-Tobacco (CR,SR)
Peridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underwood ex Heller, Bracken (CR,SR)
- * *Pycnanthemum virginianum* (L.) T. Dur. and B.D. Jackson ex B.L. Robins. and Fern., Virginia Mountain-Mint (CR)
- * *Quercus rubra* L., Northern Red Oak (CR)
Rosa acicularis Lindl. ssp. *sayi* (Schwein.) W.H. Lewis, Prickly Rose (CR,SR)
Rosa blanda Ait., Smooth Rose (CR,SR)
Rubus allegheniensis Porter, Allegheny Blackberry (CR,SR)
Rudbeckia hirta L., Black-eyed-Susan (CR,SR)
- + *Rumex acetosella* L., Common Sheep Sorrel (CR,SR)
- * *Selaginella rupestris* (L.) Spring, Ledge Spike-Moss (CR)
- + *Silene vulgaris* (Moench) Garcke, (*S. cucubalus*) Maiden's-Tears (CR,SR)
Solidago juncea Ait., Early Goldenrod (CR,SR)
Solidago nemoralis Ait. var. *nemoralis*, Gray Goldenrod (CR,SR)
- * *Spiraea tomentosa* L., Steeplebush (SR)
- * *Sporobolus cryptandrus* (Torr.) Gray, Sand Dropseed (CR,SR)
Thuja occidentalis L., Eastern Arborvitae [White Cedar] (CR,SR)
- * *Viola adunca* Sm., Hook-Spur Violet (CR,SR)
Vitis riparia Michx., River-bank Grape (CR,SR)
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Habitat Parameters and Small Mammal Associations of the Gaspé Shrew, *Sorex gaspensis*, in the Eastern Gaspé Peninsula, Québec

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Fortin, Christian, and Denis Comeau. 2008. Habitat parameters and small mammal associations of the Gaspé Shrew, *Sorex gaspensis* in the eastern Gaspé Peninsula, Québec. *Canadian Field-Naturalist* 121(2): 118-123.

The Gaspé Shrew (*Sorex gaspensis*) is one of the rarest of Canadian small mammals. Consequently, little is known about its habitat preferences. This paper documents habitat parameters and small mammal species associated with the capture of nine specimens in the Gaspé Peninsula, Québec. Small mammals were collected using both pitfall traps and Victor snap traps at 22 sites during August and September 2005. A total of 571 small mammals representing 12 species was captured during 5637 trap nights. *S. gaspensis* specimens were trapped at sites located on hilly, rocky habitats. Microhabitat was cool and moist in all cases. Slope was always over 15 degrees and altitude ranged from 29 to 240 meters. Estimated percent of moss ground cover exceeded 50% in seven of the nine capture sites. Six *S. gaspensis* were trapped near running water while the others were captured far from streams. Overall, ten species of small mammals were captured in the same sites of *S. gaspensis*. Smoky Shrew (*Sorex fumeus*) was by far the most strongly associated species.

Key Words: Gaspé Shrew, *Sorex gaspensis*, habitat, small mammals, Québec.

The Gaspé Shrew, *Sorex gaspensis*, has an eastern North American range distribution that encompasses the Appalachians of the Gaspé Peninsula of Québec and New Brunswick, and Cape Breton Island, Nova Scotia (COSEPAC 2006*). A first record of *S. gaspensis* at Forillon National Park of Canada (FNPC) in 2002 confirmed the species' distribution to the northern limit of the Appalachians (Pronovost et al. 2005*). It is one of the rarest and probably least studied of Canadian small mammals and consequently little is known about *S. gaspensis* habitat preferences. Populations appear to be restricted largely to hilly areas with steep slopes and varying amounts of rock outcrops and talus (Kirkland 1981; Scott 1988*; COSEPAC 2006*). *S. gaspensis* is associated with several other small mammals with boreal affinities, including other shrews. While they are currently recognized as distinct species, recent phylogenetic analyses suggest that Gaspé Shrew and Long-tailed Shrew (*Sorex dispar*) are conspecific (Rhymer et al. 2004). Both species have similar habitat requirements (COSEPAC 2006*).

This paper documents habitat parameters, and small mammals associated with the capture of nine specimens in the Gaspé Peninsula, Québec, in 2005. This region is a part of the range of *S. gaspensis* for which little information currently exists. Data presented here supports those reported by others.

Study Area and Trapping Sites

A total of 22 sites was sampled within Forillon National Park of Canada (245.5 km²) and on territories managed by the GESPEG Micmac Nation (1.3–4.5 km²), Gaspésie County, eastern Québec (48°55'N,

64°30'W, Appendix 1) (Figure 1), with the specific objective of capturing *S. gaspensis*. Hilly areas with moderate to steep slopes are present throughout the region although some flat lands occur locally. Elevation ranges from 0–50 m in flat areas to 500–600 m in hilly areas. The habitat of the study area was mainly mixed-forest associations, with deciduous stands in well-drained slopes and coniferous stands in poorly-drained areas, generally lower-slopes. The dominant tree and shrubs species include Balsam Fir (*Abies balsamea*), White Birch (*Betula papyrifera*), Yellow Birch (*Betula alleghaniensis*), White Spruce (*Picea glauca*), Sugar Maple (*Acer saccharum*), Mountain Maple (*Acer spicatum*), and Rough Alder (*Alnus rugosa*). Trapping site descriptions are given in Table 1.

Methods

Trapping was carried out between 15 and 27 August 2005 in the eight GESPEG sites and between 18 August and 24 September 2005 in the 14 FNPC sites. Sites were selected to represent different associations of habitat parameters. Habitat components including altitude, slope, substrate, forest type, forest age, presence/absence of running water, and presence/absence of disturbance were analysed using a geographic information system (ArcGIS), while dominant overstory species, dominant understory species, and ground cover (30 m radius) of mosses, litter, herbs, and ferns were estimated in the field.

Both pitfall traps (ice-cream containers; 0.5 L) and standard Victor snap traps were used at each of the 22 sites (Table 1). Pitfalls were partially filled with water and Victor traps were baited with peanut butter

TABLE 1. Description of the 22 *Sorex gaspensis* trapping sites within territories managed by the GESPEG Micmac nation and Forillon National Park of Canada (FNPC).

Site	Altitude (m)	Number of trapping days	Number of pitfall traps	Number of Victor traps	Forest type	Stand age	Proximity to water (<15 m)	Slope (°)
GESPEG1	121	12	10	20	Mixed	10	Yes	15-30
GESPEG2	152	12	10	20	Mixed	70	Yes	15-30
GESPEG3	80	11	10	20	Mixed	70	Yes	8-15
GESPEG4	95	11	5	10	Mixed	50	Yes	15-30
GESPEG5	111	11	10	20	Coniferous	70	Yes	15-30
GESPEG6	230	10	10	20	Deciduous	50	Yes	15-30
GESPEG7	242	10	11	18	Deciduous	50	Yes	15-30
GESPEG8	50	10	10	20	Coniferous	70	Yes	15-30
FNPC9	64	10	10	20	Mixed	50	Yes	15-30
FNPC10	10	10	10	20	Coniferous	Ua ¹	Yes	0-3
FNPC11	87	4	10	20	Coniferous	50	No	>40
FNPC12	88	10	10	20	Mixed	30	No	>40
FNPC13	129	9	10	20	Mixed	70, 30	Yes	30-40
FNPC14	31	6	10	20	Mixed	70	Yes	15-30
FNPC15	183	2	10	20	Mixed	90	Yes	15-30
FNPC16	89	10	11	18	Mixed	70	Yes	15-30
FNPC17 ²	60	11	11	18	Mixed, deciduous	50, Ua ¹	Yes, no	15-30, 30-40
FNPC18	160	7	11	18	Mixed	70, 30	Yes	15-30
FNPC19	130	10	10	20	Mixed	50	Yes	8-15
FNPC20	155	2	10	20	Deciduous	Regeneration	No	>40
FNPC21	16	10	10	10	Deciduous	50	Yes	3-8
FNPC22	25	10	10	10	Fallow land	Regeneration	Yes	3-8

¹ Uneven-aged first growth forest.² This site is subdivided into two parts.

S. gaspensis specimen trapped. Other species captured in the same sites as *S. gaspensis* were Smoky Shrew (86 specimens), Red-backed Vole (24), *Clethrionomys gapperi*, Masked Shrew, *Sorex cinereus* (17), Woodland Jumping Mouse (10), *Peromyscus* sp. (5), Short-tailed Shrew, *Blarina brevicauda* (2), Water Shrew, *Sorex palustris* (2), Meadow Vole, *Microtus pennsylvanicus* (1), and Southern Bog Lemming, *Synaptomys cooperi* (1).

Occurrence sites of *S. gaspensis* were all located on hilly, rocky habitats (Table 3). Slope was always over 15 degrees, and all occurrence sites included varying amounts of blocks, boulders and rock outcrops. In all cases, the microhabitat at the capture site was cool and moist. Estimated percent of moss ground cover exceeded 50% in seven of the nine capture sites. Relative abundance of herbs was always low. No specimen was captured on level ground and in soil composed of mainly sand and clay (three trapping sites).

All other habitat components varied to some degree from one occurrence site to another. The altitudinal range was from 29 to 240 meters (Table 3). Six of the nine *S. gaspensis* were trapped close to running water while three specimens were captured a considerable distance from the nearest streams (up to 232 m). *S. gaspensis* occurred in all three forest types (deciduous, coniferous and mixed forests), in different stand ages, and in stands with varying degree of habitat distur-

bance, such as stands defoliated by insects. Dominant overstory species included Balsam Fir, *Acer* sp. *Betula* sp. and *Picea* sp. Estimated percent of litter covered ground ranged from 0 to 75. Importance of ferns varied greatly.

Discussion

This study emphasises the importance of large, rocky substrate and moist areas as key habitat components for *S. gaspensis*. Rock formations, which include blocks, boulders and rock outcrops, occurred in all capture sites. The incidence of moss cover at capture sites reflects the cool microclimate, created either by the rock formation, canopy influence, exposure (e.g., north facing slope), topographic characteristics of the site (e.g., narrow canyon), or the proximity to water, in the form of surface or subsurface streams. These results correspond closely to information presented for *S. gaspensis* from other localities (Anthony and Goodwin 1924; Goodwin 1929; Peterson and Symansky 1963; Roscoe and Majka 1976; French and Kirkland 1983; Scott 1988*), and for *S. dispar* (Kirkland et al. 1979; Scott and van Zyll de Jong 1989; Woolaver et al. 1998; Ford and Rodrigue 2001; McAlpine et al. 2004; Shafer and Stewart 2006).

Scott (1988*) questioned the importance of running water as a habitat requirement for *S. gaspensis*. He concluded that proximity to water is probably not of

TABLE 2. Summary of captures of small mammals at 8 sites within territories managed by the GESPEG Micmac Nation and 14 sites in Forillon National Park, Québec.

Species/Site	GESPEG										Forillon National Park												TOTALS	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
<i>Sorex cinereus</i>	1	5	1		1			1		11	8	1	2	1	4		2	2	1		8	7	56	
<i>Sorex fumeus</i>	8	8	26		5	10	7	9	12	3	4	9	15	18	9	22	22	6	26	5	13	10	247	
<i>Sorex palustris</i>		4		1	2		1							1			2				1		17	
<i>Blarina brevicauda</i>		2	3									2	2				1						8	
<i>Sorex gaspensis</i>							1			1	1	1	1	1	1	1		1		2			9	
<i>Sorex hoyi</i>									1								1						2	
<i>Microtus chrotorrhinus</i>																							2	
<i>Clethrionomys gapperi</i>				1																			2	
<i>Synaptomys cooperi</i>		9	7	1	10		3	3	7	3	5	3	3	5	1	1	2	7	8				84	
<i>Microtus pennsylvanicus</i>											1												1	
<i>Napaeozapus insignis</i>			1				1		1														3	
<i>Peromyscus</i> sp		10	7	12	1	8	4	21	7			3	4		1	4		16	2	1	2	103		
TOTALS	6	34	33	51	4	27	10	18	36	33	19	19	23	28	27	14	25	40	56	10	28	20	571	
SAMPLING EFFORT (TN)	360	360	360	330	275	330	300	280	300	300	300	120	300	270	180	60	290	319	203	300	60	200	200	5637

TN = trap nights

critical importance to this species. Our results concur with this hypothesis as three of the nine specimens were captured more than 200 m from the nearest stream.

Throughout its range, *S. gaspensis* has generally been associated with steep slopes in hilly or highland areas (Scott 1988*; COSEPAC 2006*), similar to *S. dispar* (Woolaver et al. 1998; McAlpine et al. 2004; Shafer and Stewart 2006). In this study, specimens were captured on steep (30-40°) and abrupt slopes (>40°), but most of the capture sites were on moderate slopes (15-30°). This suggest that slopes over 15 degrees may provide minimal structural features (e.g. rock formation) associated with suitable habitat for this species.

There is no evidence in this study to suggest that *S. gaspensis* is restricted by altitude or structural component of the vegetation. Previous trapping studies yielded specimens at elevations ranging from 46 m (in Scott 1988*) to 610 m (Anthony and Goodwin 1924). *S. gaspensis* has been recorded in coniferous, deciduous and mixed forests and with many dominant overstory species (review in Scott 1988* and COSEPAC 2006*). Although this shrew is often associated with mature stands (Anthony and Goodwin 1924; Peterson and Symansky 1963; Scott 1988*), regenerating forest is also reported as a stand age class used by *S. gaspensis* (COSEPAC 2006*). Similarly, Woolaver et al. (1998) reviewed habitat characteristics for *S. dispar* in the United States and Canada and observed that forest type varies widely between localities.

In our study area, *S. gaspensis* is part of a diverse small mammal community with ten other species captured (nine from this study; one specimen of Pygmy Shrew, *Sorex hoyi*, was also captured in 2002, Pronovost et al. 2005*). Literature, reviewed by Scott (1988*), also reports that *S. gaspensis* has been recorded in association with several species of small mammals, including some species of shrews. *Sorex fumeus* was by far the most strongly associated species in our study area and was observed in each occurrence site of *S. gaspensis* in 2002 (Pronovost et al. 2005*) and 2005 (this study).

As *S. fumeus* is larger than *S. gaspensis*, the former is probably dominant in interspecific interactions. We propose that vertical segregation (*sensu* Churchfield 1990) may explain the persistence of *S. gaspensis* in the presence of high densities of *S. fumeus* by forming the basis of differential habitat use. This pattern of shrew coexistence has been observed in some shrew communities, with one species being primarily subterranean while the others live mostly on the ground surface (Churchfield 1990; Feldhamer et al. 1993). In our study area, we hypothesize that *S. gaspensis* is most active underground while *S. fumeus* is most active on the surface. This could explain why *S. gaspensis* was rarely captured compared to *S. fumeus*. Morphological differences between these two species could also explain this apparent coexistence (Kirkland and

TABLE 3. Habitat characteristics at the *Sorex gaspensis* capture sites.

Habitat characteristic	GESPEG 7					Capture site			
	FNPC 7	FNPC 18	FNPC 15	FNPC 20	FNPC 20	FNPC 14	FNPC 11	FNPC 16	FNPC 13
Altitude (m)	240	156	181	151	147	29	75	91	121
Slope (°)	15-30	15-30	15-30	>40	>40	15-30	>40	15-30	30-40
Distance to nearest water (m)	1	0	5	227	232	2	228	12	2
Forest type	Deciduous	Mixed	Mixed	Deciduous	Deciduous	Mixed	Coniferous	Mixed	Mixed
Stand age (years)	50	70, 30	90	Regeneration	Regeneration	70	50	Ua ¹	70, 30
Dominant overstory species ²	Be, Ab	Pi, Be	Pi, Ab, Be	Be, Ac	Be, Ac	Ac, Be, Ab	Pi, Ab, Th	Pi, Ab, Ac	Pi, Ab, Be
Disturbance ³		LID	LID	SID	SID	LID			
Dominant substrate classes ⁴	PC, BB, RO	PC, BB	CS, PC, BB	BB	BB	PC, BB, RO	PC, BB	PC, BB, RO	PC, RO
Litter (% coverage)	50	25	10	75	50	20	0	25	30
Moss (% coverage)	50	50	10	25	50	80	100	75	70
Relative abundance of ferns ⁵	2	1	2	3	1	2	0	Na	Na
Relative abundance of herbs ⁵	1	1	1	1	1	1	1	Na	Na

¹ Uneven-aged first growth forest.

² Ab: *Abies balsamea*; Ac: *Acer* sp.; Be: *Betula* sp.; Pi: *Picea* sp.; Th: *Thuja occidentalis*.

³ LID: light insect defoliation; SID: severe insect defoliation.

⁴ CS: clay and sand; PC: pebbles and cobbles; BB: blocks and boulders; RO: rock outcrops.

⁵ 0: none; 1: trace to 5% coverage; 2: 6 to 50%; 3: >50%; na: no data available.

Van Deusen 1979). *Sorex gaspensis* is more slender and has a narrowed rostrum than *S. fumeus*, allowing the former to exploit resources in the narrower crevices of rock formations which are not accessible to the more robust *S. fumeus* (Kirkland and Van Deusen 1979).

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APPENDIX 1. Locality data (NAD 83 coordinates) of the 22 *Sorex gaspensis* trapping sites within territories managed by the GESPEG Micmac Nation and Forillon National Park of Canada (FNPC).

Site	UTM north	UTM east
GESPEG1	5422234	383214
GESPEG2	5421781	382659
GESPEG3	5438652	383653
GESPEG4	5442586	377073
GESPEG5	5427348	382948
GESPEG6	5397021	394904
GESPEG7	5396893	394790
GESPEG8	5423152	377028
FNPC 9	5410839	407102
FNPC10	5411190	409697
FNPC11	5406875	410179
FNPC12	5400440	414538
FNPC13	5407193	408622
FNPC14	5412365	396743
FNPC15	5413928	398511
FNPC16	5415628	400002
FNPC17 ¹	5410855	406973
FNPC18	5410289	406213
FNPC19	5422541	390239
FNPC20	5423145	390612
FNPC21	5417349	401615
FNPC22	5417907	401156

¹ This site is composed of two parts.

Abundance Trends for *Hexanchus griseus*, Bluntnose Sixgill Shark, and *Hydrolagus coliei*, Spotted Ratfish, Counted at an Automated Underwater Observation Station in the Strait of Georgia, British Columbia

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Dunbrack, Robert. 2008. Abundance trends for *Hexanchus griseus*, Bluntnose Sixgill Shark, and *Hydrolagus coliei*, Spotted Ratfish, counted at an automated underwater observation station in the Strait of Georgia, British Columbia. *Canadian Field-Naturalist* 122(2): 124-128.

Recordings from a time lapse video monitoring station on a shallow rocky reef in the Strait of Georgia, British Columbia, revealed a steep and continuous decline in the occurrence of *Hexanchus griseus* (Bluntnose Sixgill Shark) between 2001 and 2007, with relative abundance in 2006 and 2007 less than 1% of that in 2001. The relative abundance of another chondrichthyan, *Hydrolagus coliei* (Spotted Ratfish), decreased to 15% of 2004 levels in 2005 and 2006 and remained below 25% in 2007. There is no compelling explanation for these decreases. Over the past 25 years water temperatures have increased in the Strait of Georgia and there have been a number of El Niño warm water events, but diver observations of *H. griseus* at this site over the same time period give no indication of prior changes in abundance. Neither species is targeted by a fishery, but injuries, possibly related to hooking and entanglement, observed in 28% of individually identified *H. griseus* suggests this species may be taken locally as bycatch.

Key Words: *Hexanchus griseus*, Bluntnose Sixgill Shark, *Hydrolagus coliei*, Spotted Ratfish, automated underwater video, British Columbia.

Temporal changes in the relative abundance of non-commercial fish species may provide evidence of the effects of bycatch or of environmental perturbations that is obscured in data for commercial species because of their direct exploitation. However, standard removal-based methods of assessing relative abundance can be difficult, prohibitively expensive, and unacceptably destructive, particularly for non-commercial species which are uncommon or have low rates of growth and reproduction. Some non-destructive methods of quantifying local abundance, such as counts made by diver observers or extracted from diver collected video, are also labour intensive, and may contain unknown errors due to variation in observers, methods, or areas and times surveyed (Watson et al. 2005). An alternative non-destructive methodology is the use of video recording at strategically placed fixed automated observation stations (Dunbrack and Zielinski 2003). Analysis of such video records can provide cost effective, quantitative, and accurate count data that can be used to document site-specific seasonal and year-to-year changes in abundance, behavior, sex ratio, or size composition for several species simultaneously. Such a system has been in place since June 2001 on a rocky reef in the Strait of Georgia, British Columbia, Canada, primarily to monitor seasonal and year-to-year changes in the relative abundance of two chondrichthyan species: the Bluntnose Sixgill Shark, *Hexanchus griseus*, and the Spotted Ratfish, *Hydrolagus coliei* (Dunbrack and Zielinski 2003).

Hexanchus griseus has one of the most extensive geographic ranges among vertebrates (Compagno 1984), is one of the largest fishes (length to at least 5.5 m; Clark and Kristof 1990), and may have one of the longest vertebrate lifespans. Although little is known of its population biology, *H. griseus* is probably the highest trophic level predator throughout its range (Ebert 1994; Froese and Pauly 2007*), feeding on an array of large sized prey (Compagno 1984; Ebert 1986, 1994). The chimaerid *Hydrolagus coliei* is also a deep water demersal chondrichthyan but with a more limited distribution in the coastal NE Pacific from northern Mexico to Alaska (Hart 1973). The lack of direct exploitation, combined with the low reproductive rate and deep cold water habitat of these two chondrichthyans, suggests that temporal fluctuations in their abundance could be key indicators of perturbations in continental shelf ecosystems, including changes in thermal regime.

In British Columbia, both species are found in the deep waters of the Strait of Georgia and in deeper inlets of the adjoining mainland and the west coast of Vancouver Island (Hart 1973). Movements into shallow water are strongly seasonal and in the case of *Hexanchus griseus* uncommon (Dunbrack and Zielinski 2003, 2005). However, on a shallow rocky reef adjacent to Flora Islets in the Strait of Georgia, *H. griseus* has been sufficiently abundant from June to August that a valuable dive tourism industry based on encounters with these normally deep water sharks has

existed since the 1970s (Harvey-Clark 1995). This unusual shallow water concentration of *H. griseus* prompted the establishment of an automated underwater observation station at Flora Islets that has provided largely continuous video records of the movements of *Hexanchus griseus* and *Hydrolagus coliei* along the base of the reef wall since June 2001. Initial analyses of these records documented marked seasonal changes in *Hexanchus griseus* activity at this site (Dunbrack and Zielinski 2003). This note describes year-to-year changes in the relative abundance of *Hexanchus griseus* and *Hydrolagus coliei* at Flora Islets between 2001 and 2007.

Materials and Methods

The Flora Islets study site is located in the Strait of Georgia off the SE tip of Hornby Island (49°30.9'N, 124°34.5'W). All observations were made using automated, fully submerged, time-lapse video recording (Dunbrack and Zielinski 2003). The time-lapse system consisted of a 12V black-and-white video camera (Sony model SPT-M320) and a time lapse video recorder (Sony Hi 8 EVO-250-NTSC with PGV-250 alarm recording adapter) in separate PVC housings. Between June 2001 and July 2002 the camera was on a tripod resting on the bottom, 3 m from the base of the reef wall, at a depth of approximately 40 m, and pointed along the downward sloping base of the wall. From July 2002 onward, the camera was fixed to the vertical reef wall, at a depth of 35 m, directly above the previous position, and facing downward. This vertical orientation allowed individual sharks to be identified based on dorsal scarring patterns and increased the visibility of *Hydrolagus coliei*, which were too cryptic in the horizontal view for reliable counting. The change in camera orientation did not alter the detectability of sharks inbound from deeper water, as the field of view for both orientations extended 10 m out from the base of the wall.

In time-lapse mode, video was recorded in sequences lasting 4/30 second at 8-second intervals, providing approximately 240 hours of continuous coverage with a normal 4-hour video tape. The maximum deployment time was adjusted by varying the daily "on time" with a programmable timer (e.g., 10-day deployment with a daily "on time" of 24 hours; 240-day deployment with a daily "on time" of one hour). Recording was not continuous throughout the study period because of technical difficulties, inclement weather that prevented tape and battery changes, and low light conditions associated with blooms of phytoplankton in the upper water layers. For further details of the time lapse video system see Dunbrack and Zielinski (2003).

To quantify relative abundance from the video records, a threshold visibility was defined based on the ability to distinguish a light colored target (approximately 250 cm²) 10 m from the camera position. When this visibility threshold was exceeded all sharks and ratfish observed were recorded on video in at least

two consecutive sequences (8 s apart) so that no fish should have been missed due to low visibility during count periods (visibility threshold exceeded). Counts were only made of sharks and ratfish inbound along the reef wall from deeper water and no attempt was made to identify individual fish. Counts may thus include repeat observations of the same individuals, but this should not affect the use of these counts as measures of relative abundance if fish behavior is independent of abundance.

Because of the strongly seasonal pattern of occurrence for both species, daily frequencies (fish/hour) were compared between years with data paired by calendar date. Analyses for *Hexanchus griseus* were based on day-by-day comparisons with the same date in 2001. To illustrate, for each date with recordings in 2002 and 2001, the frequency (sharks/hour) in 2002 was subtracted from the frequency in 2001 and the difference scored as positive, negative, or zero. Zeros were eliminated and a sign test was used to evaluate the null hypothesis of no difference in frequencies between years (Sokal and Rohlf 1995). This procedure was repeated for the years 2003-2007. Treatment of the ratfish data was identical, with the exception that comparisons were based on 2002, the first year *Hydrolagus coliei* was counted. To display the yearly data graphically, the frequency ratio (frequency on date *i*, year *X*)/(frequency on date *i*, 2001/2), was calculated for all dates with overlapping observations with 2001 (*Hexanchus griseus*) or 2002 (*Hydrolagus coliei*) and the mean ratios for each year plotted as a function of year.

Results

Sharks and ratfish were uncommon in September and October in all years and were virtually absent from the study site between November and May. Although both species were observed in June, there were extensive periods in this month when observations could not be made because of low illumination related to heavy phytoplankton blooms in the upper water column. Consequently, year by year comparisons of relative abundance were made for the months of July and August only.

The frequency of *Hexanchus griseus* was higher in 2001 than in any subsequent year and decreased continuously from 2001 onward, reaching a level of less than 1% of 2001 levels in 2006, with no sharks observed in 2007 (Figure 1). Frequencies in all years were significantly lower than in 2001 (Table 1). There was no significant change in the frequency of *Hydrolagus coliei* between 2002 and 2004, but frequency decreased significantly in 2005 to approximately 15% of 2002 levels and remained low in 2006 and 2007 (Figure 2; Table 2).

Discussion

Hexanchus griseus individuals at Flora Islets make only brief forays onto the reef from adjacent deep water (200-300 m), consequently the decrease in rel-

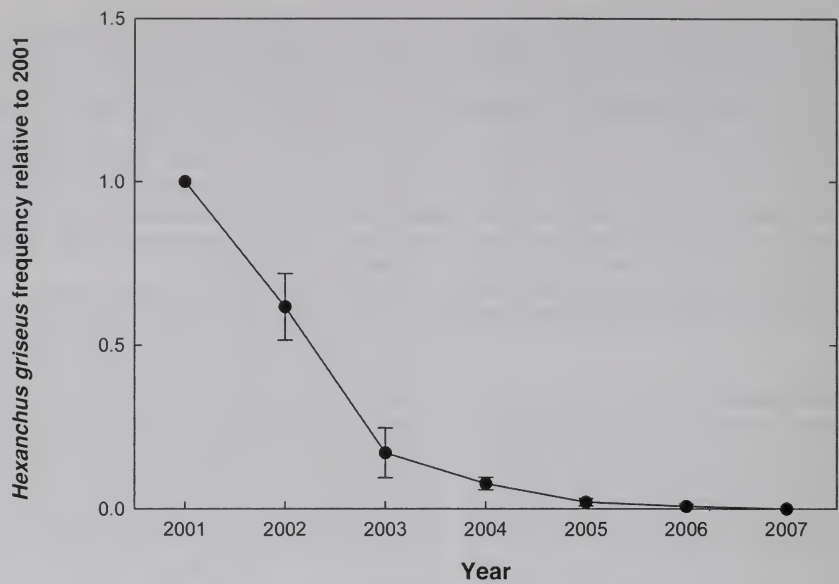


FIGURE 1. Mean frequency ratio for inbound *Hexanchus griseus* between 2002 and 2007 relative to 2001. The mean ratio for each year is the mean of the ratios calculated for each date with observational data in both the given year and 2001. Error bars represent standard errors. Lines connecting points are for illustration only and are not intended to indicate intermediate values.

ative abundance between 2001 and 2007 (Figure 1) may reflect similar changes in the local deep water population. This result is consistent with *H. griseus* sightings logged at this site by divers between 1979 and 2007. Only during the last five years do these logs show a downward trend, with diver sightings in 2005–7 being the lowest over the 25 years of observations (A. Heath and R. Zielinski, Hornby Island Diving, Hornby Island, British Columbia, unpublished data).

The cause of this apparent change in relative abundance, and its geographic scale, is unclear. Water temperatures, which can have a significant effect on habitat quality for fishes (Helfman et al. 1999), vary seasonally between 8° and 10°C in the deeper parts of the Strait of Georgia, but began a slow increase in the last decades of the 20th century and are currently about 1° warmer than in 1970 (D. Masson, Institute of Ocean

Sciences, Sydney, British Columbia, personal communication). However, diver logs do not indicate a corresponding decrease in sightings between 1979 and 2000, nor during warm water anomalies associated with four El Niño events between 1980 and 2000. A decrease in abundance of *H. griseus* has also been noted anecdotally for a nearby site in Barkley Sound on the west coast of Vancouver Island. Here, sixgill sharks were regularly seen by divers during the 1980s and early 1990s, but sightings became rare after 1997 (N. McDaniel, Subsea Enterprises, Vancouver, British Columbia, personal communication; P. Mieras, Rendezvous Diving, Port Alberni, British Columbia, personal communication; R Dunbrack, unpublished observation). The effect of a commercial fishery for *H. griseus* in this area between 1991 and 1993 (Harvey-Clark 1995) is unclear.

TABLE 1. Sign tests of year to year comparisons of *Hexanchus griseus* frequency with July and August 2001. The sample size, *n*, is the number of overlapping days with at least one hour of observations and does not include ties. The positive score is the number of days on which frequency in 2001 exceeded that on the same date in the given year. *P* values are for two-tailed tests.

Year	2002	2003	2004	2005	2006	2007
	<i>n</i> = 46	<i>n</i> = 18	<i>n</i> = 43	<i>n</i> = 48	<i>n</i> = 48	<i>n</i> = 40
	+ = 36	+ = 17	+ = 43	+ = 48	+ = 48	+ = 40
	- = 10	- = 1	- = 0	- = 0	- = 0	- = 0
	ties = 1	ties = 0	ties = 0	ties = 0	ties = 0	ties = 1
	<i>P</i> < 0.0002	<i>P</i> < 0.0002	<i>P</i> < 0.0001	<i>P</i> < 0.0001	<i>P</i> < 0.0001	<i>P</i> < 0.0001

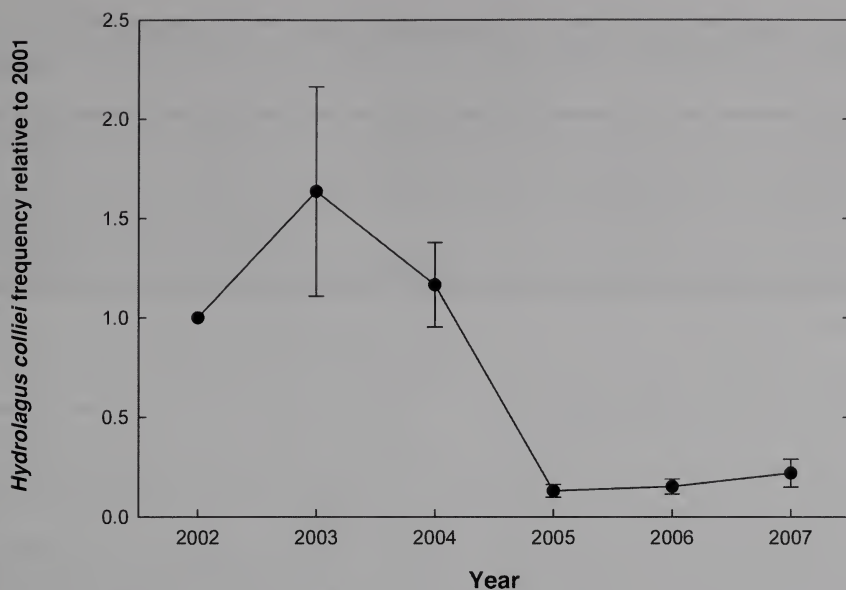


FIGURE 2. Mean frequency ratio for inbound *Hydrolagus collieri* between 2003 and 2007 relative to 2002. The mean ratio for each year is the mean of the ratios calculated for each date with observational data in both the given year and 2002. Error bars represent standard errors. Lines connecting points are for illustration only and are not intended to indicate intermediate values.

It is likely that the decrease in abundance of *Hydrolagus collieri* at Flora Islets also reflects a similar decrease in the local deep water population, but there are no historical observational data available for this species for comparison with the decline from 2004 to 2005/2006/2007. It is unknown how changes in the thermal regime of the Strait of Georgia might effect *H. collieri* populations.

There is currently no fishery for either species in the Strait of Georgia, but both are taken locally in gear set for dogfish (COSEWIC 2007). Although the extent of this bycatch is not well documented (COSEWIC 2007), there is evidence of an unusually large bycatch of *Hexanchus griseus* in the Strait of Georgia in 2002 (COSEWIC 2007). There is also visual evidence of detrimental effects of commercial fishing gear on individuals observed at Flora Islets. Overhead, close range video taken at Flora Islets in 2001 and 2002 showed that 10 of 35 individually identified *H. griseus* had wounds consistent with hooking and entanglement (Dunbrack and Zielinski 2005; Dunbrack 2006), a figure that probably underestimates injury frequency because overhead observations were confined to either a shark's right or left hand dorsal side; the jaw region, where most hooking injuries are observed by divers, was not visible. Injuries to *Hydrolagus collieri* individuals would not be detectable because of the fish's small image size on the video records.

The life histories of these two species in the north eastern Pacific are poorly understood but there is evi-

dence suggesting habitat separation between adult and juvenile *Hexanchus griseus*. Stereo video length measurements of 35 individuals observed at Flora Islets ranged from 135 cm to 353 cm, all below the length at maturity for *H. griseus* (Dunbrack and Zielinski 2005; Dunbrack 2006). In addition, the collection, in the Strait of Georgia, of neonates, as well as a single female with near term embryos, suggests that these deep inshore waters are used for birth and juvenile rearing, but that mating occurs offshore (Dunbrack and Zielinski 2005). There is no information on the population biology of adults in offshore waters. However, even small increases in yearly adult mortality in a long lived species such as *H. griseus*, possibly due to the same anthropogenic factors responsible for recent declines in most large marine fishes (Myers and Worm 2003), would eventually be expressed in decreased abundance of juveniles inshore.

The observations reported here demonstrate that low cost, continuous, non-destructive, video monitoring of the marine environment in key habitats can provide evidence of changes in the abundance of uncommon species that would otherwise go unnoticed. These are the first quantitative multi-year abundance data for either species; consequently, the downward trends at Flora Islets cannot be viewed in the context of longer term, or geographically more extensive, data. Nonetheless, such decreases call for further investigation as they may provide early evidence of more widespread perturbations in the marine environment and may invoke

TABLE 2. Sign tests of year to year comparisons of *Hydrolagus collei* frequency with July and August 2002. The sample size, n , is the number of overlapping days with at least one hour of observations and does not include ties. The positive score is the number of days on which frequency in 2002 exceeded that on the same date in the given year. P values are for two-tailed tests.

Year	2003	2004	2005	2006	2007
	$n = 10$	$n = 35$	$n = 41$	$n = 41$	$n = 32$
	$+ = 5$	$+ = 23$	$+ = 40$	$+ = 40$	$+ = 30$
	$- = 5$	$- = 12$	$- = 1$	$- = 1$	$- = 2$
	ties = 1	ties = 0	ties = 0	ties = 0	ties = 0
	NS	NS	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$

government mandated initiatives aimed at maintaining local marine biodiversity and ameliorating the detrimental effects of fisheries bycatch on vulnerable species, such as these long lived and slow growing chondrichthyans (Castro et al. 1999). In particular, the reduction of *H. griseus* at this site to less than 1% of its 2001 abundance might suggest it may qualify for threatened or endangered status under the regional modifications of the IUCN Red List criteria (World Conservation Union 2001*; Gardenfors et al. 2001) adopted by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2005*), an approach suggested for other deep water demersal species that have undergone similar regional declines (Devine et al. 2006).

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Anurans in a Subarctic Tundra Landscape Near Cape Churchill, Manitoba

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Distribution, abundance, and habitat relationships of anurans inhabiting subarctic regions are poorly understood, and anuran monitoring protocols developed for temperate regions may not be applicable across large roadless areas of northern landscapes. In addition, arctic and subarctic regions of North America are predicted to experience changes in climate and, in some areas, are experiencing habitat alteration due to high rates of herbivory by breeding and migrating waterfowl. To better understand subarctic anuran abundance, distribution, and habitat associations, we conducted anuran calling surveys in the Cape Churchill region of Wapusk National Park, Manitoba, Canada, in 2004 and 2005. We conducted surveys along ~1-km transects distributed across three landscape types (coastal tundra, interior sedge meadow-tundra, and boreal forest-tundra interface) to estimate densities and probabilities of detection of Boreal Chorus Frogs (*Pseudacris maculata*) and Wood Frogs (*Lithobates sylvaticus*). We detected a Wood Frog or Boreal Chorus Frog on 22 (87%) of 26 transects surveyed, but probability of detection varied between years and species and among landscape types. Estimated densities of both species increased from the coastal zone inland toward the boreal forest edge. Our results suggest anurans occur across all three landscape types in our study area, but that species-specific spatial patterns exist in their abundances. Considerations for both spatial and temporal variation in abundance and detection probability need to be incorporated into surveys and monitoring programs for subarctic anurans.

Key Words: Boreal Chorus Frog, *Pseudacris maculata*, Wood Frog, *Lithobates sylvaticus*, subarctic tundra, Manitoba.

Declining amphibian populations have received increased attention in North America (Bury et al. 1995) and elsewhere (Alford and Richards 1999; Burrows et al. 2004; Stuart et al. 2004; Lips et al. 2005). Factors implicated in the decline of North American amphibians inhabiting temperate regions include habitat fragmentation and loss (Johnson 1992), pollution (Bishop 1992), and global climate change (Herman and Scott 1992; Ovaska 1997; Pounds 2001). Changes in global temperatures and increased intensity of UV-B radiation predicted in climate change models (Kickert et al. 1999) could influence the distribution and abundance of anurans throughout North America (Mandronich 1993; Ovaska 1997; Pounds 2001). Arctic and subarctic regions of North America are predicted to experience dramatic changes in climate (Mandronich 1993). Anurans in these northern regions are at the edges of their distribution and environmental tolerances, and will likely be affected by changes in climate (Ovaska 1997). For example, increasing average temperatures may result in expansion of some anuran species into regions formerly too cold to support them (Ovaska 1997), but increasing UV-B radiation could have a significant negative effect on the growth and survival of some anurans (Crump et al. 1999).

Changes in some arctic and subarctic landscapes due to high rates of herbivory by breeding and migrating waterfowl (Ankney 1996), especially Lesser Snow Geese (*Chen caerulescens caerulescens*; Kerbes et al. 1990; Jano et al. 1998) might also influence anurans in these landscapes. Herbivory rates have increased substantially along with the exponential increase of Lesser Snow Goose populations, which are thought largely to result from anthropogenic influences on their wintering grounds (Ankney 1996). Extensive feeding on below ground biomass by Snow Geese in tundra meadows and wetlands may reduce the abundance of small wetlands (Abraham and Jefferies 1997) and change the chemistry of the remaining aquatic habitats, influencing their suitability to support anuran reproduction (Jefferies 2000). Recent data, from near Cape Churchill in Manitoba, suggested anuran abundance was lower in tundra wetlands with higher impacts on vegetation from goose herbivory when compared to areas with less impacted vegetation (Mannan 2008). Overall, however, the status of anurans inhabiting subarctic regions remains poorly understood. Because of this, the effects of habitat loss or alteration, and global climate change on anurans in arctic and subarctic regions cannot be assessed.

Declines in amphibian populations have resulted in recent efforts to establish standardized monitoring programs for amphibians in North America (e.g., North American Amphibian Monitoring Program; Bishop and Petit 1992; Heyer et al. 1994; Weir and Mossman 2004) although these monitoring efforts have not been extended to subarctic regions. Anurans have been reported to occur in the vicinity of Churchill, Manitoba (Shelford and Twomey 1941; Wrigley 1974), but there are no data available concerning anurans on the Hudson Bay Lowlands within Wapusk National Park in Manitoba, Canada. During a pilot study in June 2002, we detected both Wood Frogs (*Lithobates sylvaticus*) and Boreal Chorus Frogs (*Pseudacris maculata*) on standardized surveys in Wapusk National Park. Based on these preliminary surveys (C. W. Boal and D. E. Andersen, unpublished data), we initiated a project in 2004 to assess anuran density, distribution, and habitat associations in the tundra and boreal forest-tundra ecotone of Wapusk National Park. Specifically, we collected data to (1) describe anuran species composition in the region and (2) compare the probability of detection and density of anurans across years, species, and three landscape types.

Study Area

The Hudson Bay Lowlands in Manitoba are an area of low-lying tundra and northern boreal forest ecosystems along the western shores of Hudson Bay (Figure 1). They extend from southern James Bay in Ontario (52°54'N, 82°10'W) northwest to just north of the town of Churchill, Manitoba (59°27'N, 94°53'W). South of Cape Churchill and within Wapusk National Park (11 475 km²) lies a narrow strip of coastal tundra habitat where coastal salt marshes, beach ridges, and freshwater sedge meadows compose the major habitat types (Didiuk and Rusch 1979; Brook 2001). In this region, the northern boreal forest begins ~10 km from the Hudson Bay coastline. The climate is influenced strongly by Hudson Bay, which can remain frozen for up to 9 months of the year. Average daily temperatures ranged from -26.7°C in January to 12°C in July. Average monthly precipitation ranged from 15.7 mm in February to 68.3 mm in August (Environment Canada, www.climate.weatheroffice.ec.gc.ca).

Methods

Landscape classification

We used ArcView® 3.3 (Environmental Systems Research Institute, Inc. © 1992 – 2002; use of trade names does not imply endorsement by the U.S. Geological Survey, the University of Minnesota, or Texas Tech University), the vegetation classification layer developed by Brook (2001), and habitat categorizations by Didiuk and Rusch (1979) to delineate that portion of Wapusk National Park north of the Broad River and east of the western edge of La Pérouse Bay into three landscape types based on physiography and

vegetation: (1) Coastal beach ridge – sedge meadow (BRSM), (2) Interior sedge meadow (ISM), and (3) Boreal forest – tundra interface (TRAN; Figure 1). The BRSM stratum (~330 km²) extended from the high tide line to approximately 3–5 km inland. This stratum was characterized by low relief, continuous permafrost, poor drainage, beach ridges, coastal marshes, and coastal tundra vegetation (Wellein and Lumsden 1964; Didiuk and Rusch 1979). The ISM stratum (~394 km²) began at the western edge of the BRSM stratum and extended westward toward the northern boreal forest edge. This stratum was characterized by reduced numbers of beach ridges, extensive sedge and grass meadow complexes, and shallow water bodies. The TRAN stratum (~397 km²) began where spruce (*Picea* spp.) trees became increasingly present and consisted primarily of lichen spruce bog, sphagnum spruce bog, lichen melt pond bog, and sedge meadow vegetation types (Brook 2001). Combined, these strata extended from Cape Churchill (58°50'N) south to the mouth of the Broad River (58°10'N) and from the Hudson Bay coastline (93°05'W) west to La Pérouse Bay (95°30'W).

Transect surveys

In 2004 and 2005, we used ArcView® 3.3 to randomly establish coordinates for the origin of 1-km transects in each stratum. To maximize sample size (i.e., number of transects surveyed) in 2005, we randomly located coordinates ≥3 km from any of the 2004 transects. We were transported by helicopter to each starting location. At the origin, we generated a random compass bearing along which to traverse the transect. When a random bearing would send the survey crew through impassable terrain (e.g., lakes, rivers) we randomly selected an alternative bearing. We waited 5 minutes after the helicopter departed, landed near the end of the transect, and shut down before beginning a survey to reduce bias from helicopter disturbance.

Because we had few anuran detections on preliminary surveys conducted at points along transects surveyed in 2002 (C. W. Boal and D. E. Andersen, unpublished data), we used unbounded transects to survey anurans in 2004 and 2005, and recorded all aural and visual detections of anurans along transects. The primary observer walked each transect and recorded a track of the survey route using a handheld Global Positioning System (GPS) unit. At each anuran detection, the observer recorded the species detected, Call Index Value [CIV: 1 = individuals counted, no overlap between calls; 2 = individuals counted but calls overlap; 3 = full chorus, calls are constant and overlapping (Weir and Mossman 2004)] by species, estimated distance and bearing from transect line to calling anurans (estimated with a laser rangefinder and a compass), general landscape and vegetation characteristics, weather conditions, and time of day of the observation. We recorded multiple detections from the same location off the transect as a single detection so as to

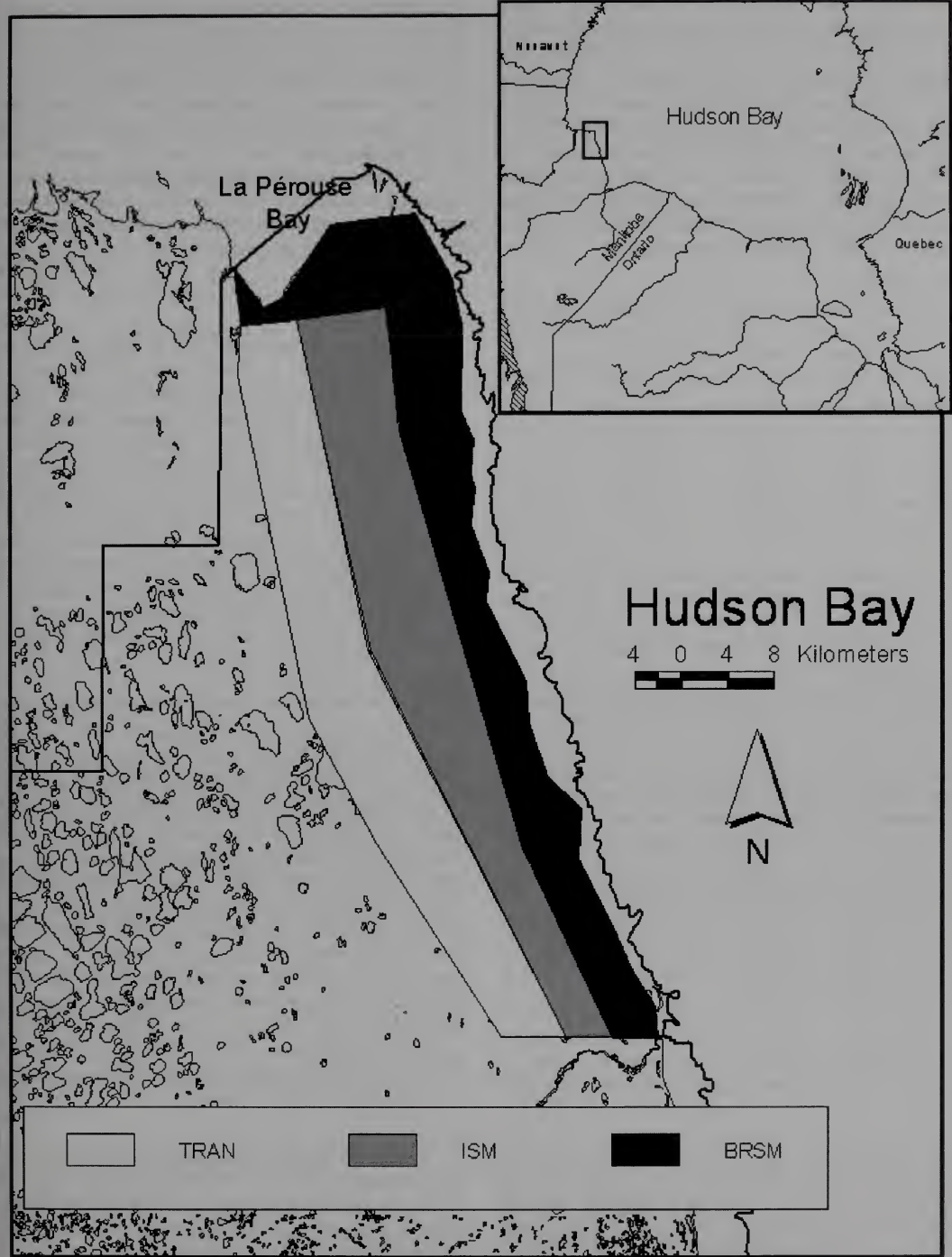


FIGURE 1. Three vegetation/physiographic strata at Cape Churchill: beach ridge-sedge meadow (BRSM), interior sedge meadow (ISM) and boreal forest-tundra interface (TRAN) within Wapusk National Park, Manitoba.

not double count anurans. We followed North American Amphibian Monitoring Program (NAAMP) weather protocols (www.pwrc.usgs.gov/NAAMP/protocol) and did not survey in rain or in winds > Beaufort 4 (~25–30 km per hr). In addition, because anurans in these landscapes call during daylight hours in June at this latitude (Manann 2008), there are not periods of complete darkness, and because Polar Bears (*Ursus maritimus*) are a safety concern, especially during twilight periods when they are harder to detect, we conducted surveys during daylight hours.

Data analysis

We used program DISTANCE (Thomas et al. 2005) to analyze transect data from 2004 and 2005 and fit detection function models. We ranked models using Akaike's Information Criterion corrected for small sample size (AIC_c ; Burnham and Anderson 2002). Because of the low number of detections for some species in some strata, we pooled data to increase sample size and precision of density estimates derived from DISTANCE. We followed methods described in Buckland et al. (2001) to assess the validity of pooling across years, species, and strata. We assessed frequency of detection as a function of distance from the transect to determine whether anurans on the transect line were detected with probability equal to 1 (an assumption of distance sampling). Our qualitative analyses indicated that anurans close to the transect line were detected at lower frequency than those away from the line. We corrected for this possible observer effect on the probability of detection by removing all detections at <10 m from the transect during analysis in DISTANCE, and assuming the probability of detection at 10 m was one. Anuran detections of CIV 2 or CIV 3 indicated that >1 frog was present and we incorporated cluster size (i.e., how many animals were present) in DISTANCE. We used the CIV score of each detection as a relative measure of the number of anurans present (e.g., CIV of 2 indicated 2 anurans present). This approach resulted in minimum density estimates.

We fitted four separate general detection functions (uniform, half-normal, negative-exponential, hazard rate; Buckland et al. 2001) to model the observed decline in anuran detections as a function of distance from the transect in the analysis of each of the following scenarios: (1) Anuran detections were pooled across species and strata to compare between years (hereafter, YEAR); (2) Detections of each species were pooled across years and strata to compare between Wood Frogs and Boreal Chorus Frogs (hereafter, SPECIES); (3) Anuran detections were pooled across species and years to compare among strata (hereafter, STRATA). Due to the low number of detections in some scenarios, we allowed only one cosine adjustment term in detection function models. We used the model best supported by the data (e.g., lowest AIC_c) to estimate the probability of detection (\hat{p}) and anu-

ran density (\hat{D}) for each year, species, and stratum. Because we were also interested in variation within species across strata, but the number of detections was too small to estimate a detection function with reasonable precision, we calculated the encounter rate (ER = the number of detections per km surveyed) for each species within each stratum. We pooled data across years to calculate encounter rates and evaluated variation in encounter rates between species within strata, and among strata within species, by comparing 95% CI (Buckland et al. 2001).

Results

Transect summary

We surveyed 15 transects (five in each stratum) in 2004 and 11 transects (three in the BRSM stratum and four in both the ISM and TRAN strata) in 2005. We conducted surveys from 29 June to 2 July 2004 between 0930 and 1900 CDT and from 14 to 19 June 2005 between 0922 and 1526 CDT. We surveyed a total of 24.6 km, with transects ($n = 26$) averaging 946 m ($SE = 18$) in length. Five transects were <900 m in length due to helicopter noise interference (e.g. the pilot started the helicopter prior to completion of a survey) or when the presence of a lake prevented surveying to the end of a transect. Surveys averaged 55 minutes to complete in 2004 and 64 minutes in 2005.

Anuran detections

Year

In 2004, we detected ≥ 1 frog on 11 (73%) of 15 transects and in all three strata. We detected anurans aurally on 77 occasions. In 2005, we detected anurans on all 11 transects and in all three strata. We detected anurans aurally on 75 occasions and visually on two occasions (both were Wood Frogs). We used 64 detections in 2004 and 66 detections in 2005 for analysis with DISTANCE. Two detection function models received substantial support ($\Delta AIC_c < 2.0$) in 2004, and four models received substantial support in 2005. Employing the models with the lowest AIC_c for each year (Table 1), the estimated probability of detection was higher in 2005 ($\hat{p} = 0.32$) than in 2004 ($\hat{p} = 0.13$), based on a comparison of 95% CI. Although 95% CI overlapped, density estimates were over 2 times higher in 2004 than in 2005 (Table 2).

Species

Overall, we detected a Wood Frog, Boreal Chorus Frog, or both species on 22 (87%) of 26 transects surveyed. We used 65 detections for analysis of both Wood Frogs and Boreal Chorus Frogs in DISTANCE. Based on ΔAIC_c , one detection function model received substantial support for Wood Frogs, and three models were supported for Boreal Chorus Frogs (Table 1). The best-supported models of detection resulted in estimates of probability of detection only slightly higher for Boreal Chorus Frogs ($\hat{p} = 0.17$) than for Wood Frogs ($\hat{p} = 0.14$; Table 2). The estimated density of Wood

TABLE 1. Summary of detection function model selection for YEAR, SPECIES, and STRATA using program DISTANCE for Wood Frogs and Boreal Chorus Frogs at Cape Churchill, Manitoba. Models were ranked using Akaike's Information Criterion (AIC_c) corrected for small sample sizes, and evaluated with ΔAIC_c (AIC_c - minimum AIC_c) and Akaike weights (w_i). k was the number of estimable parameters in the model.

		Model	AIC _c	ΔAIC _c	w _i	k
YEAR	2004	Hazard rate	278.32	0.00	0.54	2
		Hazard rate w/ cosine	279.14	0.82	0.36	3
	2005	Half-normal	349.94	0.00	0.31	1
		Negative exponential w/ cosine	349.97	0.43	0.25	2
		Hazard rate w/ cosine	350.15	0.61	0.23	3
		Half-normal w/ cosine	351.57	1.96	0.12	2
SPECIES	Wood Frog					
		Hazard rate	300.90	0.00	0.55	2
	Boreal Chorus Frog	Negative exponential	338.55	0.00	0.44	1
		Negative exponential w/ cosine	340.44	1.89	0.17	2
		Half-normal	340.48	1.93	0.17	1
STRATA	BRSM	Negative exponential	132.30	0.00	0.29	1
		Uniform w/ cosine	132.84	0.54	0.22	1
		Half-normal	132.87	0.57	0.22	1
		Negative exponential w/ cosine	134.01	1.71	0.12	2
	ISM	Half-normal	172.71	0.00	0.32	1
		Negative exponential w/ cosine	172.97	0.26	0.28	2
		Negative exponential	174.59	1.88	0.12	1
	TRAN	Negative exponential	321.05	0.00	0.39	1
		Hazard rate	321.51	0.46	0.31	2

TABLE 2. Probability of anuran detection (\hat{p}) and estimated density (\hat{D} = anurans per km²) of anurans at Cape Churchill, Manitoba derived from program DISTANCE when anuran detections were (1) pooled across species and strata, within each year (YEAR), (2) pooled across years and strata, within each species (SPECIES), and (3) pooled across years and species, within each stratum (STRATA). Models listed are detection functions that best fit the observed data given the models assessed based on Akaike's Information Criterion (AIC_c).

		Model	\hat{p}	95% CI	\hat{D}	95% CI
YEAR	2004	Hazard rate	0.13	0.08, 0.20	102.25	51.61, 202.55
	2005	Half-normal	0.32	0.26, 0.39	49.87	34.86, 71.36
SPECIES	Wood Frog	Hazard rate	0.14	0.09, 0.23	56.76	29.78, 108.20
	Boreal Chorus Frog	Negative exponential	0.17	0.12, 0.23	38.90	23.33, 64.97
STRATA	BRSM	Negative exponential	0.32	0.17, 0.59	18.46	7.40, 46.06
	ISM	Half-normal	0.30	0.22, 0.40	34.34	18.56, 63.55
	TRAN	Negative exponential	0.09	0.07, 0.12	354.66	236.32, 532.78

Frogs (\hat{D} = 56.8 per km²) was higher than for Boreal Chorus Frogs (\hat{D} = 38.9 per km²), although 95% CI overlapped (Table 2).

Strata

During 2004 and 2005 surveys, we detected anurans on five (63%) of eight transects in the BRSM stratum. We detected Wood Frogs on three (38%) and Boreal Chorus Frogs on five (63%) of the eight BRSM transects. The estimated encounter rate for Wood Frogs (0.38 detections per km) was lower than for Boreal Chorus Frogs (2.41 detections per km), although there

was a slight overlap of 95% CI (Table 3). CIVs varied by species and year (Figure 2A). In both 2004 and 2005, we detected more Boreal Chorus Frogs than Wood Frogs; however, overall total detections of both species were few along BRSM transects.

We detected anurans on eight (89%) of nine transects surveyed in 2004 and 2005 in the ISM stratum. We detected both Wood Frogs and Boreal Chorus Frogs ≥ 1 time on six (67%) of nine transects. Estimated encounter rates for Wood Frogs and Boreal Chorus Frogs were 2.64 and 1.15 detections per km, respectively (Table 3). CIV 1 and CIV 2 were most common

TABLE 3. Encounter rates (*ER*) for Wood Frogs and Boreal Chorus Frogs within each of three general landscape stratum at Cape Churchill, Manitoba, calculated as the number of detections (*n*) divided by the distance traversed (*L*).

Species	Stratum	<i>n</i>	<i>L</i> (km)	<i>ER</i> (<i>n</i> / <i>L</i>)	95% CI
Wood Frog	BRSM	3	7.88	0.38	0.09, 1.69
	ISM	23	8.73	2.63	1.14, 6.09
	TRAN	39	8.40	4.64	2.83, 7.62
Boreal Chorus Frog	BRSM	19	7.88	2.41	1.05, 5.54
	ISM	10	8.73	1.15	0.34, 3.82
	TRAN	36	8.40	4.29	2.65, 6.92

for both Wood Frogs and Boreal Chorus Frogs, and we detected few (*n* = 1) full choruses (CIV = 3; Figure 2B).

We detected anurans on all nine transects surveyed in the TRAN stratum in 2004 and 2005. We detected Wood Frogs and Boreal Chorus Frogs ≥ 1 time on all transects we surveyed. Encounter rates for Wood Frogs and Boreal Chorus Frogs were 4.64 and 4.29 detections per km, respectively (Table 3). We recorded a steady chorus (CIV = 3) of Wood Frogs on all or part of three of five transects in 2004, but in 2005, all Wood Frog detections (*n* = 16) were discernable individuals (CIV = 1; Figure 2C). We detected Boreal Chorus Frogs 14 times in the TRAN stratum in 2004 and 25 times in 2005. The only time we detected a full chorus of Boreal Chorus Frogs was in the TRAN stratum in 2004.

Overall, we encountered Wood Frogs more often in the TRAN stratum than in the BRSM stratum, but there were no differences between encounter rates in ISM and TRAN or BRSM and ISM strata based on 95% CI (Table 3). We also encountered Boreal Chorus Frogs most frequently in the TRAN stratum, but there were no significant differences in encounter rates among strata (Table 3). After pooling across species and years, we used 22, 33, and 75 detections in DISTANCE to model the detection function for BRSM, ISM, and TRAN strata, respectively. Four models received substantial support in the BRSM stratum, three models in the ISM stratum, and two models in the TRAN stratum (Table 1). Based on the model with the lowest AIC_c for each stratum, the probability of detection was highest in the BRSM ($\hat{p} = 0.32$) stratum and declined heading inland to the ISM ($\hat{p} = 0.30$) and then TRAN ($\hat{p} = 0.09$) strata. The 95% CI for the estimated probability of detection overlapped between ISM and BRSM; however, the probability of detection in the TRAN zone was substantially lower, and its 95% CI did not overlap with that of either the BRSM or ISM strata (Table 2). Estimates of anuran density were highest in the TRAN stratum ($\hat{D} = 354.66$ per km²), then progressively, and substantially, decreased the farther the survey was from the TRAN stratum, with $\hat{D} = 34.34$ per km² in ISM and $\hat{D} = 18.46$ per km² in BRSM (Table 2). Similar to the species-specific encounter rates, pooled species density estimates across

strata also decreased from the TRAN to the ISM to the BRSM stratum.

Discussion

Despite extensive annual surveys for frogs and amphibians throughout much of North America (Weir and Mossman 2004), little is known about anuran species composition, landscape distribution, and general habitat associations in subarctic regions. We found Wood Frogs and Boreal Chorus Frogs in all three landscape types that we sampled in the subarctic region near Cape Churchill, Manitoba. Although our estimates suggested that the probability of detecting an anuran differed between 2004 and 2005, there was not a significant difference in estimated anuran densities across the study area between those two years. Probability of detection can be influenced by weather conditions such as wind, barometric pressure, and temperature (Oseen and Wassersug 2002). We are aware of no data describing the influence of weather variables on the detection of anurans in tundra habitats; however, recently initiated studies near Cape Churchill are designed to evaluate the effect of these factors on detection rates (D. E. Andersen, unpublished data). In this study, we conducted surveys in weather conditions deemed suitable for conducting surveys in more temperate regions of North America (Weir and Mossman 2004) to minimize the influence of weather on our results.

Seasonal and diurnal patterns in anuran calling behavior (Oseen and Wassersug 2002) can also influence detection probability of anurans, although calling patterns of anurans in subarctic and arctic landscapes, where daylight can extend for ≥ 20 hrs in summer, are not well documented. Manaán (2008) reported anuran calling throughout the day and peak calling in the afternoon by both Boreal Chorus Frogs and Wood Frogs during June in a coastal tundra landscape near Cape Churchill. Although we conducted our surveys throughout the day in both years, we conducted some surveys later in the day in 2004 than in 2005. This may have influenced detection probabilities. In both years, our surveys occurred approximately 2 weeks prior to the median hatch date of Canada Geese (*Branta canadensis*) in the region, which is tied very closely to annual spring phenology and is variable among years (Walter 1999). Factors that influence Canada Goose

nest initiation, such as snow melt, also likely affect the timing of reproduction of anurans.

Wood Frogs and Boreal Chorus Frogs were the only anurans we detected during our surveys, and the probability of detection and estimates of density were nearly the same for both species. Peak calling in the majority of anuran species is associated with the initiation of the breeding season (Wells 1977), so detection of anuran species is likely influenced by reproductive ecology. Wood Frogs in temperate regions are spring breeders (Oseen and Wassersug 2002) and Boreal Chorus Frogs also typically call early in the season (Corn and Muths 2002). The similarity in the breeding season of these species may have contributed to the similar estimates of probability of detection. However, temporal variation in calling behavior of these species in subarctic regions is unknown and inferences drawn from our estimates of density are limited by our study design, which incorporated logistical constraints imposed by working in a remote, subarctic landscape.

We did not detect anurans uniformly across our study area, nor were they distributed uniformly, with both Wood Frogs and Boreal Chorus Frogs generally increasing in abundance from coastal to transition strata. The probability of detecting anurans was equivalent in the BRSM and ISM strata, but much lower in the TRAN stratum. Wind speed likely influences detection probability (personal observation) and has been shown to influence calling in some anuran species (Oseen and Wassersug 2002). In 2005, average measured wind speeds (km per hour) were substantially higher on transects in the ISM (12.23 km per hr) and TRAN (11.08 km per hr) strata than in the BRSM strata (5.78 km per hr) and may have contributed to some of the observed variation in the probability of detection along this same gradient. We were unable to statistically test for an influence of weather variables because we surveyed relatively few ($n = 26$) transects, and because we were constrained to surveying multiple transects on the same day. However, we minimized weather influences on our ability to compare anuran abundance across strata and years by conducting surveys within NAAMP guidelines, although how well these guidelines apply in subarctic landscapes is not known. Moderate winds are generally present on our study area, and both Boreal Chorus Frogs and Wood Frogs call when winds exceed Beaufort 4 (personal observation), suggesting that we conducted surveys under conditions when anurans were likely to call.

The high intensity of calling anurans in the TRAN stratum, especially near transects (<50 m), may have limited the probability of detection of anurans farther away, resulting in a low overall probability of detection. Based on DISTANCE analyses, the TRAN stratum had a significantly smaller effective strip width (22 m) than either the ISM (76 m) or BRSM (80 m) strata. In contrast, density of anurans (species combined) increased substantially from the BRSM stratum

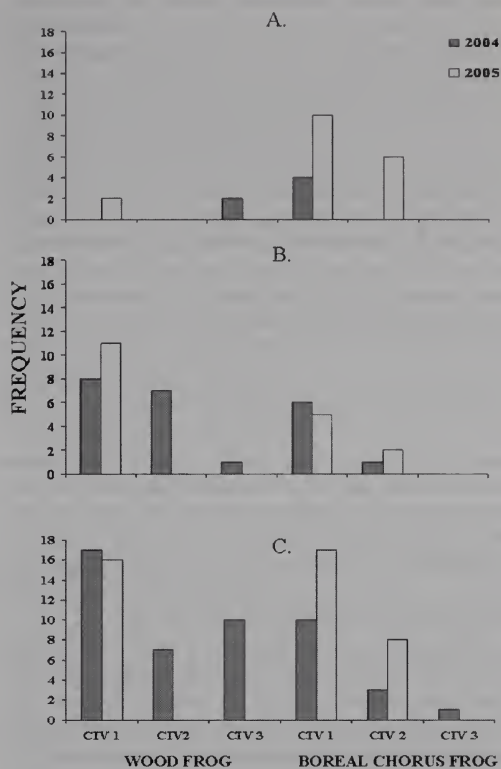


FIGURE 2. Frequency of each level (1, 2, and 3) of call index values (CIV) observed for each anuran species (Wood Frog or Boreal Chorus Frog) in each year (2004 or 2005) in the (A) beach ridge-sedge meadow (BRSM), (B) interior sedge meadow (ISM) and (C) boreal forest-tundra interface (TRAN) in Wapusk National Park, Manitoba.

to the TRAN stratum. We similarly encountered Wood Frogs with higher frequency along the same gradient from BRSM to TRAN strata. However, we encountered Boreal Chorus Frogs more frequently in the BRSM stratum than in the ISM stratum, but most frequently in the TRAN stratum.

The magnitude of variation in encounter rates across strata was less than variation of density estimates derived using DISTANCE, and was most likely due to incorporating the cluster size of detections (i.e., how many animals are present) in DISTANCE. We used the CIV score of each detection as a relative measure of the minimum number of anurans present. These minimum density estimates were likely more appropriate than the relative measure of anuran abundance derived from encounter rates, which do not account for either the number of anurans present at each detection location or the probability of detection being <1 .

Estimated density and encounter rates were highest in the TRAN stratum. Weather conditions in the BRSM

and ISM strata are strongly influenced by Hudson Bay, which can remain frozen for up to 9 months of the year. Even though both Wood Frogs and Boreal Chorus Frogs are able to survive through harsh winter conditions using cryoprotectants, they may experience greater survival and reproductive success in the comparatively milder conditions that exist near the boreal forest edge (Herreid and Kinney 1967). Conditions conducive to breeding may arrive earlier in the spring farther from Hudson Bay resulting in spatial variability in calling anurans. More complex vegetative structure near the boreal forest may also provide more and better hibernacula and cover from predators for both adults and larvae. Coastal areas are also where there is currently the greatest overlap between waterfowl, wetland impacts from waterfowl herbivory, and anurans, and where we observed the lowest anuran densities. However, recent studies suggest the distribution of habitat use by geese is changing in this region (e.g., Nack and Andersen 2006) with geese increasingly using inland meadows for feeding. This may increase the extent of overlap between waterfowl and anurans, which may influence the future distribution and abundance of anurans in this region.

Although we pooled data across years, species, and strata, our sample sizes (i.e., the number of detections) were relatively small for distance analyses, primarily due to logistical and fiscal constraints of surveying an area accessible only by foot or helicopter during spring and summer. Furthermore, the utility of distance sampling is limited when species are rare and detections are few (Buckland et al. 2001). In the ISM and BRSM strata, we detected both Wood Frogs and Boreal Chorus Frogs infrequently, and thus estimates of detection probability and density were imprecise. We also were unable to use DISTANCE to estimate the probability of detection or density for each species within each of the three landscape types due to the low number of detections in the BRSM and ISM strata. Future surveys could incorporate increased sampling effort in some landscape types to obtain enough detections to precisely estimate density. In addition, our data suggested that anuran behavior may be influenced by observers. Anuran detection frequency within 10 m of transects was lower than detection frequency farther from transects. In our analyses, we accounted for an observer effect by removing detections <10 m from transects and assuming the probability of detection was one at 10 m. However, this truncation reduced sample size. Alternative methods that would reduce possible observer effects on detections should be considered for future anuran surveys in this region.

Ours is one of the first studies to examine detection and patterns of distribution and density of anurans at a landscape scale in a subarctic tundra ecosystem. Because arctic and subarctic regions are projected to experience dramatic changes in climate, and because biotic factors (e.g., intensive and extensive foraging

by waterfowl) have already affected arctic and subarctic landscapes, it is imperative to better understand current anuran distribution and abundance. Our data provide a critical first assessment of the distribution and ecology of subarctic-dwelling anurans in the Hudson Bay Lowlands and highlight some of the factors necessary to consider when developing programs to monitor anurans in arctic and subarctic regions.

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Bullsnake, *Pituophis catenifer sayi*, Nesting Biology in Alberta

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Bullsnakes were opportunistically observed at a site on Alberta's Red Deer River at the northern extreme of their range near the town of Drumheller. This site is significant for its importance to the local nesting ecology of this snake. Data were collected from captured snakes, and individuals were marked and photographed to enable identification upon subsequent recapture. A minimum of 39 adult Bullsnakes were known to utilize a single bluff over a period spanning five years from 1998 to 2002. Fifteen gravid females were found over this span nesting in a single burrow complex. Bullsnakes were found to excavate their own nesting burrows at the site, and to show nest site fidelity. The congregation of numbers of these snakes at localized sites of importance to nesting biology renders them potentially vulnerable, and may present conservation challenges.

Key Words: Bullsnake, *Pituophis catenifer sayi*, nesting, hibernacula, fidelity, northern limit, Alberta.

The northern limit of Bullsnake, *Pituophis catenifer sayi*, range occurs somewhat north and west of Drumheller, Alberta, Canada along the Red Deer River, on the Northern Fescue Prairie ecotype (Kissner and Nicholson 2003*). At this latitude, the microclimates occurring within the systems of coulees, bluffs and gorges associated with this river and its tributaries are likely necessary for the successful reproduction of this species. Records at this general latitude that place this species much west or north of Drumheller, in places not linked to the Red Deer River coulee system (Russell and Bauer 2000), are therefore either suspect as being in error or are for individuals ranging beyond the reproductive limit for the species.

Bullsnakes are designated as a "sensitive" species in Alberta and "data deficient" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Among the critical habitats that need to be protected for their conservation are nesting sites. This may be especially critical towards the northern edge of the species' range, where suitably warm nest sites may be limited. In Alberta, the warm microclimates of the coulees and gorges of the Red Deer River provide suitable conditions for the incubation of eggs. In this paper, I describe nesting biology as observed during the period 1998 to 2002 on one particular bluff of this system ("Bullsnake Bluff"; 51°25'12"N, 112°36'51"W;). Bullsnake Bluff, overlooking the Red Deer River, and approximately 190 by 90 m in extent, is of southerly exposure and apparently has more friable soil than that of adjacent bluffs, arguably allowing for easy excavation of nests. I was motivated to investigate this site when I observed an obviously gravid Bullsnake entering a hole on this bluff. This was subsequently termed "Nest Site #1". This nest was located within a vertical bank, a sub-feature of the bluff approximately 1 m high and running parallel to its face. It was thereby acces-

sible through the horizontal excavation of a "window" into the nest chamber, and repairable using water and local substrate subsequent to each opening. Focus was directed on this particular nest. Here I record observations of Bullsnakes utilizing this nest and the bluff in general.

Methods

Reconnaissance of the nesting-site and surrounding bluff was made on foot, with the greatest amount of focused effort occurring during the Bullsnake nesting period of June through mid-July. Effort was also focused on spring emergence time (from first week of April) and fall denning time (late September – early November) to locate hibernacula.

The original nest site (Nest #1) was opened during visits to the bluff, and closed again with rocks and moistened substrate from the site before leaving. Snakes were captured as encountered inside the nest chamber, on the surface adjacent to the nest, or elsewhere on the bluff. They were sexed visually or by probing, and if female, were noted as being in gravid, non-gravid, or post-oviposition condition. I weighed and measured (snout-vent length) each snake. Snakes were marked using a unique ventral scale-clipping code, and their unique dorsal head markings were photographed. Selected individuals ($n = 11$), representing a sample of the overall size range of gravid females, were retained in captivity until they laid their eggs. The resultant clutches were weighed in their entirety, sample measurements were taken of individual eggs, and the eggs were subsequently incubated on moistened (not damp) vermiculite in a closed, ventilated plastic box placed inside an indoor terrarium with controlled temperatures characterized by 24-hour fluctuations from approximately 22 to 32°C, similar to the range noted to occur inside Nest #1. Date of oviposition was noted,

as was incubation period. Hatchlings were weighed collectively and an average hatchling weight calculated for the clutch.

The opened nest-chamber dimensions were measured and sketched, and side tunnels noted. On nine sample occasions immediately upon opening, air temperatures were taken inside the nest chamber and contrasted with the outside air and substrate temperatures. An ANOVA test was run on these three groups to determine statistical significance of temperature differences.

Additional nesting sites were recorded as found, but no effort was made to excavate these to avoid excessive intrusion. Excavating activities of female snakes, either on the surface or inside the nest chamber, were noted as encountered. Other features that appeared important to the snakes, such as holes that were not apparently nest sites, were noted.

Results

A minimum of thirty-nine adult Bullsnares [twenty-five females, five males, and nine unsexed additional adult snakes documented by unique head-patterns detectable on recovered shed-skins] utilized this bluff over the five-year period. The upper and middle portions of the bluff were most heavily utilized for nesting.

The peak period of movement to the nesting sites for the five-year period occurred consistently between 8 June and 16 July. The smallest adult snakes were the last to arrive. The period of oviposition, based on females taken temporarily from the bluff into captivity over the five-year period, is from 12 June to 22 July. The mean clutch size was 16 ($n = 11$; range: 8–26), with a direct positive relationship between body size and number of eggs laid. The mean incubation period, based on captive conditions, is 53 days. Shed skins from wild-hatched neonates at the bluff begin appearing at nest entrances as early as 17 August. The mean egg weight at oviposition is 30.2 g. The smallest documented gravid females were 1120 mm SVL ($n = 2$).

The "main" or "antechamber" (first chamber encountered by entering Bullsnares) of Nest #1 (Figure 1) was approximately 76 cm long by 41 cm deep by 18 cm high. The anterior inside wall of the chamber was approximately 15 cm deep, measured from the exposed earth face of the approximately 1 m high vertical formation into which the nest had been excavated from above. The entrance was at the west end and above the chamber, with a tunnel running more or less horizontally for approximately 15 cm before dropping vertically a roughly equal distance into the chamber. At the east end of the chamber was an exit into a second tunnel, which likely led to subsequent nest chamber(s), because neonate shed skins were found projecting from this tunnel when the antechamber was opened in late summer.

Egg shells (at least 20) and neonate shed skins were found in the antechamber when it was original-

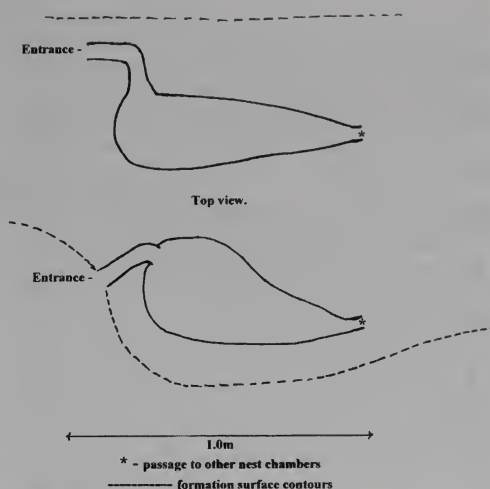


FIGURE 1. Diagram for nest number 1.

ly opened. Multiple resting Bullsnares (as many as five at a time) were often found in this antechamber; however, neither eggs, nor evidence of eggs, were found in the antechamber other than when originally opened. I hypothesize that the frequent opening of the antechamber lowered the humidity levels to the point at which the environment was unsuitable for incubation, the female snakes instead resorting to laying their eggs in an adjacent chamber or chambers, as verified by the location of neonate sheds.

On nine occasions when the antechamber of Nest #1 was opened during the peak nesting period, its inside air temperature was recorded with a digital thermometer. These openings coincided with varying weather conditions: cool and sunny, mild and rainy, and warm and sunny. The antechamber temperatures were compared to the ambient air and outside substrate temperatures at the time of opening and appeared from the sample to be on average intermediate to these, and comparatively more stable (Figure 2). These temperature differences were not statistically significant ($F = 1.92$, $df = 2$, $P > 0.10$), but a larger sample might have shown an effect on the development of the eggs.

Five other nests were found at Bullsnares Bluff, four of which were identified by snake tracks and "dump piles" – soil left characteristically by excavating Northern Pine Snakes (*Pituophis melanoleucus melanoleucus*; Burger and Zappalorti 1991) – along with the sheds of hatchling Bullsnares found at the entrance to the nests in late summer. A fifth nest was identified when excavated on 12 June 1998 in the top section of a rounded clay "knob" formation, 12 cm beneath the surface of the formation, and approximately 30 cm deep horizontally from the entrance hole on the southwest-facing side of the formation. It contained 17 Bullsnares eggs and was the only nest located in a substrate

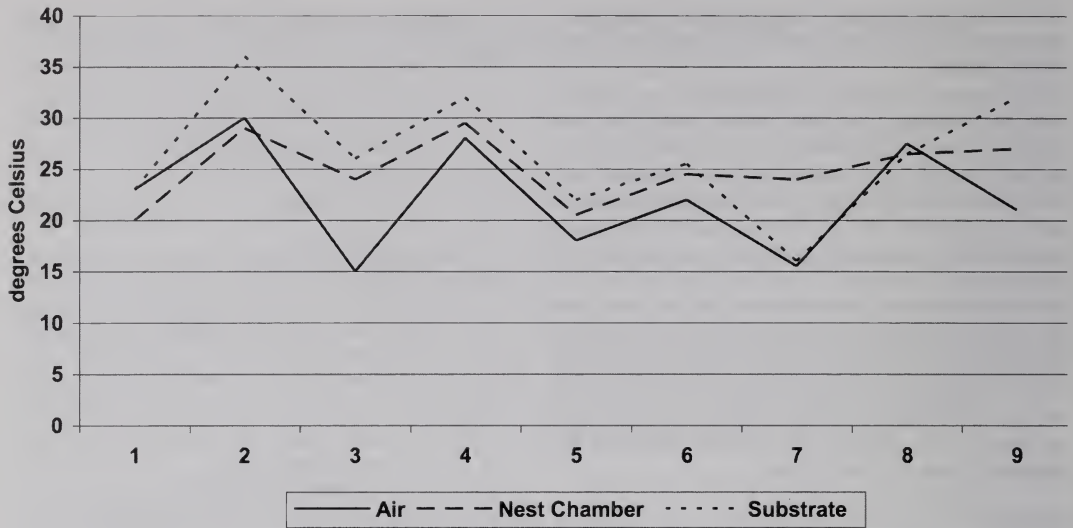


FIGURE 2. Sample temperatures at nest number 1.

type that would not have been easily excavated by the snake itself, and may have been a rodent burrow.

Bullsnakes of both sexes were found in the antechamber of Nest #1 outside the nesting period. Northern Pine Snakes are known to excavate "summer dens" not used for oviposition (Burger et. al. 1988), but I have found no record of them using nests as summer dens. Conversely, I have found no evidence of the Bullsnakes excavating burrows specifically for use as shelters outside the nesting season. The formations at Bullsnae Bluff are riddled with cracks, fissures, sink-holes and other tunnels, which provide ready-made retreats for the snakes.

Discussion

Bluffs with a southerly exposure are known to be important to the general biology of Bullsnakes elsewhere at the northern periphery of their range (Kapfer et. al. 2008). Bullsnae Bluff is important as a communal nesting site for Bullsnakes on two levels. First, Nest #1 (and probably other nests like it) is a communal nest complex with a single entrance that hosts numerous females, similar to nest sites recorded for the Great Basin Gopher Snake (*P. c. deserticola*) in British Columbia (Shewchuk 1996). Secondly, there is the bluff site in its entirety, characterized by multiple nest sites over its face and an obvious draw for nesting Bullsnakes over an unknown radius, and on a level that was not evident on adjacent bluffs. Additionally, the Bullsnakes at Bullsnae Bluff exhibit nest site fidelity to the bluff and to the specific nest, although not necessarily to the specific nest in a given year. A female may exhibit fidelity to a given nest

for several years, only to select a different nest site on the Bluff in a subsequent year, even while the original nest site is still being used as such by other females. The minimum of fifteen females known to utilize Nest #1 over a limited period is notably greater than the maximum of four females per-nest recorded for the Northern Pine Snake (Burger and Zappalorti 1986), the taxon for which communal nesting in *Pituophis* has been most thoroughly documented. Known Bullsnake nests documented at Bullsnae Bluff other than Nest #1 were not excavated for purposes of examination to avoid disturbing snakes and perhaps rendering the sites unusable.

The substrate at Bullsnae Bluff, while friable, was heavier than the sand I have examined at other Bullsnake nesting sites in Alberta. Loose, sandy substrate on a south-facing aspect appears to be important to the subspecies *P. c. deserticola* in British Columbia, and rodent burrows are sometimes modified and enlarged by the female of this subspecies, although there appears to be no record of this subspecies excavating its own burrows (Shewchuk 1996). Bullsnakes, however, like the Northern Pine Snakes which are known to dig their own nests (Burger and Zappalorti 1991), are characterized by a similar, heavier skull structure better adapted to burrowing than that of *P. c. deserticola*, (Knight 1986). Bullsnakes at Bullsnae Bluff have indeed been witnessed digging their own burrows utilizing the method described by Carpenter (1982) for Bullsnakes and by Burger and Zappalorti (1991) for Pine Snakes.

Bullsnakes have additionally been captured inside the antechamber of Nest #1 in the process of beginning excavation of side-chambers. Gravid females

have been observed on the surface of the bluff traveling slowly and digging "pre-test holes" as described for Pine Snakes in New Jersey (Burger and Zappalorti 1991) by probing the substrate with their snouts, apparently testing the suitability of the soil for excavation. Dump piles of soil were not only located outside nest burrows at Bullsnaek Bluff, but inside the antechamber of Nest #1 as well. Female Bullsnaekes in gravid and post-ovipositional states at Bullsnaek Bluff sometimes showed considerable abrasion of the rostral scale, presumably resulting from burrowing behavior. In extreme cases, the rostral showed some minimal bleeding, and at least one female had permanently worn down her rostral scale, presumably again by nest-digging.

Localized landscape features are likely important to local Bullsnaek populations. Nest sites may be important to aspects of Bullsnaek biology not only during the period of oviposition, but also at intervals throughout their active season. The congregation of these large snakes at sites characterized by specific and locally uncommon features renders them potentially vulnerable to predation, and especially to collectors. A conservation challenge here is to monitor and protect these sites from collection and disturbance by enlisting reporting by an informed and concerned public while simultaneously encouraging and facilitating further study without undue disruption of the nesting process.

Acknowledgments

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Reproduction and Mortality of the High Arctic Wolf, *Canis lupus arctos*, in Northeast Greenland, 1978-1998

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Reproduction and mortality of the High Arctic Wolf (*Canis lupus arctos*) in northeast Greenland were investigated through a temporal and spatial analysis of data on litter sizes from direct counts of pups during 21 years (1978-1998). A minimum of 22 pups were produced in a total of six areas. Overall mean litter size was 2.0 pups/litter. This was the lowest mean litter size recorded for Wolves in North America through observations of pups in summer and was probably related to low availability and vulnerability of ungulate prey. Pack size and litter size were very strongly positively correlated. Large packs (4-7 adults) produced significantly more pups than smaller packs. Mean maximum litter size from 17 North American studies employing similar methods, suggested that maximum productivity of wolves in Greenland was 58% below that of wolves elsewhere. The number of Wolf pups born in North America was negatively correlated with increasing latitude. Eight mortalities were identified and were predominantly caused by humans despite the fact that this Wolf population inhabits a national park with year-round protection.

Key Words: Arctic Wolf, *Canis lupus arctos*, litter size, pup production, mortality, northeast Greenland.

Little information has been published on productivity and mortality of Wolves (*Canis lupus arctos*) in the High Arctic. Most reports have consisted of incidental sightings of Wolf pups on the Canadian Arctic Archipelago during fieldwork by researchers in a variety of fields (Soper 1928; Grace 1976; Miller and Russell 1977; Miller 1978; Gray 1983; Gray 1993). Three notable exceptions have included a systematic, 10-year study of behavioral ecology and productivity of a Wolf pack on Ellesmere Island (Mech 1995), an analysis of sightings of wolves throughout the Canadian Arctic Archipelago, including sightings of 16 litters (Miller and Reintjes 1995), and a four-year study of Wolves on central Baffin Island (Clark 1971*). These efforts suggested that productivity of Wolves on the Canadian Arctic Islands was lower than that of Wolves in sub-arctic ecosystems, and that pups were not produced during some years. Recent information on the causes of mortality of Wolves in the Canadian High Arctic has been lacking, but some information was published on human-caused mortality at a weather station and a settlement on Ellesmere Island (Riewe 1975, 1977; Grace 1976). Little is known about reproduction and mortality of Wolves in Greenland. Brief reports of incidental sightings of Wolf pups have been published, but no comprehensive, quantitative analysis has been conducted on litter sizes and frequencies of reproduction, primarily because insufficient and fragmentary material was available. Causes of mortality of Greenland Wolves have not been documented. About 94% of Wolf range is located inside the boundaries of the Northeast Greenland National Park (Figure 1), where Wolves receive year-round protection from hunting. Human-caused mortality was therefore not likely to be an

important factor inside the park but could be important outside its boundaries due to opportunistic hunting by people from the Inuit settlement of Ittoqqortoormiit.

Objectives of this study were to (1) fill in gaps in knowledge by analyzing spatial and temporal attributes of known reproduction and mortality of Greenland Wolves and (2) to compare this information with trends in pup production across latitudes in North America. An analysis of sightings of Wolf pups in Greenland during 21 years (1978-1998) could reveal useful information pertaining to litter sizes and frequencies of reproduction. I also postulated that human-caused mortality would not constitute a substantial ratio of known mortality, because the majority of the Wolf population was protected inside the national park and because the permanent human population inside the park consisted of only approximately 27 persons, all of whom were geographically concentrated at a weather station and three year-round military outposts.

Methods

Reproduction

Four methods were employed to gather data on productivity of Wolves in northeast Greenland. First, I conducted specialized Wolf surveys lasting between two weeks and two months during May through August for eight consecutive years (1991-1998) for a total of 244 days in the field. Surveys were conducted in areas of northeast Greenland where coincidental sightings of Wolf pups had been made by members of expeditions during previous years. Dens were located during July. Two active dens were monitored, until an accurate litter count was obtained (Marquard-Petersen 1994). Second, >100 persons who had first-hand knowledge

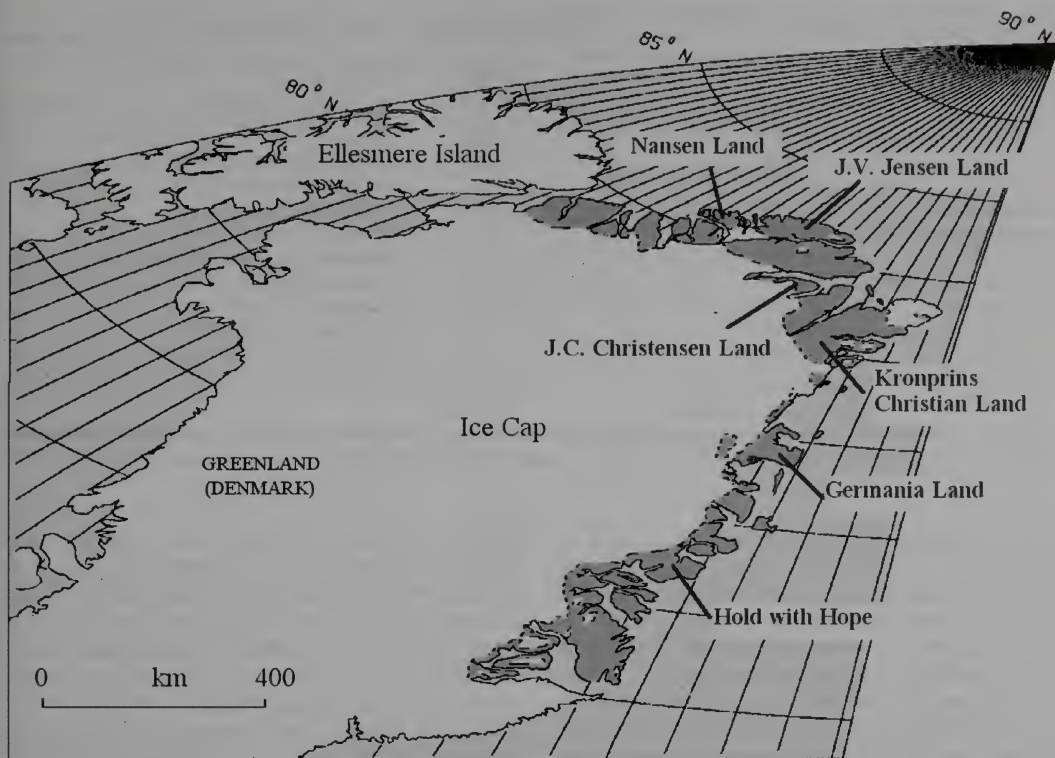


Figure 1. Wolf range (shaded area) and locations of known Wolf reproduction in Greenland, 1978-1998.

of northeast Greenland were interviewed in person or by mail to provide information about number of pups and adults observed, time, place, additional witnesses, and any documentation (photo, video). Third, all 62 field reports by expeditions during the same period were reviewed. Fourth, literature review. Not all reports of sightings were considered sufficiently reliable, especially those referring to tracks of adult Wolves accompanied by Wolf pups. All sightings and unpublished sources were detailed in Marquard-Petersen (2007*).

Mortality

Data on Wolf mortality were collected from knowledgeable individuals at military bases, the weather station Danmarkshavn, in Ittoqqortoormiit, and through food items in Wolf scats for a related study (Marquard-Petersen 1998). The Danish Military served as the police authority in the national park, and their recently declassified archives were searched to acquire police reports on the killing of Wolves other than through legal harvest.

Statistical Analysis

Single-factor analysis of variance (ANOVA) was used to test for statistically significant differences be-

tween mean litter sizes in Greenland, on the Canadian Arctic Archipelago, and in the rest of North America (H_0 : All means were equal). Because the sample size from Greenland was small, I did not rely on an assumption of normality but used normal probability plotting to see if the data resembled the normal shape. I then completed a formal Anderson-Darling test which is valid for sample sizes ≥ 8 and which provides a conservative estimate in the presence of ties, i.e., level of significance is smaller than nominal level (D'Agostino 1986). An F-test was used to check the ANOVA assumption of equal population variances, because sample sizes were small (McPherson 2001). Logarithmic transformation was used to meet the assumptions of parametric statistics. A Tukey multiple comparison post-hoc test with unequal sample sizes was used to determine between which population means differences existed (H_0 : All means were equal).

I used a one-tailed Mann-Whitney U-test to test whether mean litter size differed significantly between large packs (≥ 4 Wolves) and small packs (≤ 3 Wolves) (H_0 : Large packs were not having significantly more pups than small packs). I used a nonparametric test, because log and square root transformations failed to

TABLE 1. Known Wolf productivity in Greenland, 1978-1998

Area	Year	Adults Seen (present) ¹	Pups	Reference
Hold with Hope	1988	2	2	Turner and Dennis 1989
	1990	2	2	Burton 1990
	1992	6	3	Marquard-Petersen 1994
	1995	(5)	1	Marquard-Petersen 2007*
Germania Land	1988	4	2	Maagaard 1988
South. Kronprins Chr. L.	1993	0 (2)	1	Marquard-Petersen 2007*
	1994	1	1	Marquard-Petersen 2007*
J.C. Christensen Land	1997	1	1	Marquard-Petersen 2007*
J.V. Jensen Land	1993	5	3	Marquard-Petersen 2007*
	1994	1	3	Marquard-Petersen 2007*
Nansen Land	1985	2 (7)	3	Dawes et al. 1986; Bennike et al. 1989
$\bar{x} \pm \text{SE East Greenland}$			2.0 \pm 0.32	
$\bar{x} \pm \text{SE North Greenland}$			2.0 \pm 0.45	

¹ Number of adults actually seen with the pups. Number of adults known to be present given in parentheses.

achieve normality or to stabilize the variances. I assumed that all pups in a single litter came from one female. This assumption seemed reasonable given the low prey density (see Marquard-Petersen 2007*, in press), making it extremely unlikely that multiple females in the same pack had produced pups.

I used linear regression to examine the relationship between pup production and pack size or latitude. Residuals were summed and plotted to detect potential presence of bias in the regression models and to evaluate the need for transformation. Normality was checked using normal probability plots and formal tests, using either the Anderson-Darling test or the Shapiro-Wilk W statistic depending upon the presence of ties (Shapiro and Wilk 1965; see also Zar 1999; Sahai and Ageel 2000).

Statistical tests were conducted on computer using MINITAB, Release 14 and Microsoft Excel (see Fleming and Nellis 2000; Bernstein and Rowe 2001) supplemented by *Analyze-it for Microsoft Excel* (Analyze-it Software Ltd.). Statistical significance was at the 0.05 level.

Results

Reproduction

During the period 1978 to 1998, at least 11 litters were produced in six areas. Two areas were located in East Greenland; four were located in North Greenland (Figure 1). Pups were observed by me during one summer only (Marquard-Petersen 1994). Wolves were probably not denning in or near the other areas of fieldwork as evidenced by a low density of fresh tracks. Of the people interviewed, nine provided information on sightings of Wolf pups or dens. The literature review identified five published records of Wolf litters in Greenland and six unpublished records. Overall mean litter size was 2.0 pups/litter (SD = 0.9). Mean litter size of Wolves in North Greenland did not differ from that

of Wolves in East Greenland (Table 1). Known pup production in Greenland was highest during the period 1992-1994. There was a very strong positive correlation between Greenland Wolf pack size and pup production ($r = 0.91$; $P = 0.0001$). The difference in pup production between large and small packs was statistically significant (Mann-Whitney $U = 1.0$, $n = 11$, $P = 0.004$). Details on pup sightings and den sites in individual areas are given in Marquard-Petersen (2007*). One-way ANOVA and Tukey tests on mean litter sizes suggested that Wolves in northeast Greenland have significantly ($F_{[2, 225]} = 11.13$, $P < 0.0001$) fewer pups than: (a) Wolves on the Canadian Arctic Archipelago (mean = 4.2 pups/litter, $q = 4.91$, $df = 225$) and (b) the contiguous parts of North America (mean = 5.1 pups/litter, $q = 7.38$, $df = 225$). Average litter size in Greenland was the lowest reported for Wolves during summer using similar methods (Table 2).

Mortality

Eight mortalities were identified and were predominantly caused by humans (Table 3). No signs of disease were reported. Three Wolves were shot in separate incidents after conflicts with tethered sled dogs. Two of these were males; one was killed by the military and one by personnel at Danmarkshavn weather station. Both killings occurred after the Wolves repeatedly had been fighting with tethered dogs. One female Wolf was killed accidentally when shot with bird pellets as a deterrence after frequenting Danmarkshavn for an extended period. This female mated with sled dogs (Maagaard and Graugaard 1994), and eventually became a nuisance to station personnel. Of the remaining five mortalities, two Wolves were harvested legally by Inuit hunters in Jameson Land, one was killed by ecotourists who apparently misinterpreted inquisitive behavior for aggression, and two died from unknown causes. Remains of one of these Wolves were found

TABLE 2. Average litter sizes reported for Wolves in North America as determined by sightings of pups during summer (May-September)

Location	Latitude	Litter Size		Range	Reference
		$\bar{x} \pm SD$	n		
Northeast Greenland	70-83°N	2.0±0.9	11	1-3	Present study
Ellesmere Island	76-82°N	3.0	1	—	Grace 1976
		3.3±1.8	8	1-6	Mech 1995
		5	1	—	Marquard-Petersen 2007*
		5	1	—	Marquard-Petersen 2007*
SW Queen Elizabeth Islands	74-78°N	4.0±3.3	6	1-10	Miller and Russell 1977
		3	1	—	Miller 1998*
		3.6±1.1	5	2-5	Gray 1993
		1	1	—	Marquard-Petersen 2007*
		3	1	—	Marquard-Petersen 2007*
Banks Island	71-74°N	4	1	—	Marquard-Petersen 2007*
		6	1	—	Marquard-Petersen 2007*
		4.7±1.0	6	3-6	Clark 1971*
Central Baffin Island	69°N	4.7±1.0	6	3-6	Clark 1971*
Northern Alaska	68°N	5.3±1.5	3	4-7	Chapman 1977*
		2	1	—	Haugen 1987*
Northern mainland Canada	65°N	3.5±0.7	2	3-4	Kelsall 1960
		3.5±1.6	11	1-6	Kuyt 1972
		5.5±0.5	2	5-6	Williams 1990*
		5.2±1.1	5	4-6	Murie 1944
Denali Park, Alaska	64°N	3.0	1	—	Chapman 1977*
		5.9±1.8	7	4-9	Haber 1977*
		3.8±2.8	73	1-9	Mech et al. 1998
		5.8±1.0	28	2-9	Ballard et al. 1987
Northern Alberta	58°N	4.4±1.1	5	3-6	Carbyn 1975*
		5.0±1.6	5	3-7	Fuller and Keith 1980 ¹
Montana/British Columbia	50°N	6.0±0.8	8	5-7	Ream et al. 1991
Northern Minnesota	49°N	6.4±1.6	8	4-9	Stenlund 1955*
		3.2±1.4	13	2-6	Mech 1977 ²
		4.9±1.4	15	3-7	Fritts and Mech 1981
Isle Royale, Michigan	48°N	7.0	1	—	Peterson 1977
Southeastern Ontario	46°N	6.4±1.6	8	4-9	Pimlott et al. 1969*

¹Using minimum estimates from the authors' Table 2.²Declining prey population (Van Ballenberghe and Mech 1975)

in a Wolf scat (Marquard-Petersen 1998). The skeletal remains of the other Wolf were found by a military sled patrol in March 1993 at Krumme Langsø, O. Rømer Land. I examined the skull of this animal at Daneborg in July 1993. It showed what appeared to be a foreshortening of the rostrum that had caused the lower canines to wear furrows into the proximal side of the upper canines. Unlike workers in some other areas on North America (Carbyn 1975*; Pletscher et al. 1997; Peterson et al. 1998), no Wolf carcasses were found during the field work.

Discussion

Reliability of Data

Were these primarily incidental, non-systematic sightings in summer reliable indicators of productivity of Wolves in Greenland? There was some evidence from other areas to suggest that they were. Ten years of field research on a Wolf pack on Ellesmere Island showed that early pup survival was high (100%) and constant, because all pups that emerged from the den

were still alive when the investigator left the study area in August of each year (Mech 1995). On central Baffin Island, during the summers of 1965-1969, known pup survival until three or four months of age was 89%, and mortality was limited to a single incident where three pups presumably drowned during a river crossing (Clark 1971*). In Alaska, average pup survival during summer was at least 91% in Denali Park (Mech et al. 1998) and perhaps up to 97% in the Nelchina Basin during the first six months of life (Ballard et al. 1987). On the Kenai Peninsula, Alaska, pup survival was 80% between May and October (Peterson et al. 1984). On the Alexander Archipelago, southeast Alaska, high survivorship of pups was noted during three summers (Person 2001*). Taken together, these studies suggest that the Greenland data fairly accurately reflect the number of pups that emerged from the den.

Other factors supported accuracy of the data. In all but two cases, one or more adult Wolves were seen with the pups. Litters of Wolf pups typically play and travel with adults as a group until about eight weeks

TABLE 3. Summary of mortality data from eight Wolves known to have died in northeast Greenland, 1985-1998.

Date of Death	Location	Sex	Estimated Age	Cause of Death	Comments
27 June 1985	Germania Land: Danmarkshavn	M	Unknown ¹	Shot	Killed after conflicts with sled dogs.
26 August 1988	Hold with Hope: Badlanddalen	F	7-10 years ²	Shot	Killed by ecotourists.
September 1992	Jameson Land: Nordøstbugt	M	1-3 years ³	Shot	Killed by Inuit hunter.
-/-/1993	O. Rømer Land: Krumme Langsø	?	1-3 years ³	Unknown	Carcass found by military patrol.
-/-/1993	Germania Land: Danmarkshavn	F	Unknown ¹	Shot	Killed accidentally (shotgun blast).
-/-/1995	Peary Land: Frigg Fjord	-	Unknown ¹	Unknown	Wolf remains found in a wolf scat.
19 April 1996	Kronprins Chris. Land: Sta. Nord	M	Unknown ¹	Shot	Killed after conflicts with sled dogs.
January 1998	Jameson Land: Constable Point	M	Unknown ¹	Shot	Killed by Inuit hunters.

¹ Carcass was destroyed and unavailable for inspection.

² Age estimated based upon tooth wear.

³ Age estimated based upon tooth wear. Teeth showed no signs of normal wear.

of age when they start making short trips alone (Packard et al. 1992), increasing the likelihood that all pups were present. The frequent involvement of helicopters allowed observers to hover or move in for a closer look. An accurate count was facilitated by treeless terrain. These facts support the data, making it less likely that additional pups were overlooked. Sample size was small, but was comparable to that reported in other studies of Wolves in the High Arctic (Mech 1995: $n = 8$; Miller and Reintjes 1995: $n = 11$). It was noteworthy that it took 21 years to accumulate the 11 sightings analyzed here. Thus, procuring a large sample size of 30 in this extraordinarily remote region could take as long as the year 2030 at the present level of human activity and known frequency of reproduction. Other authors conducting fieldwork involving Wolf pups in the High Arctic have noted similar difficulties in their data collection (Packard et al. 1992). Nonetheless, litter sizes should be considered minimum pup production, as some pups could have died soon after birth. Observations of presumably complete Wolf litters in summer have also been reported by others (Fritts and Mech 1981; Ballard et al. 1987; Fuller 1989; Ream et al. 1991) and during studies of other canids; e.g. African wild dogs (*Lycaon pictus*, Creel et al. 2004). Total counts are rarely possible (Van Ballenberghe et al. 1975).

Litter Sizes

Lower mean litter sizes have been reported by others, but calculations included packs that produced no pups (Mech 1977; Fritts and Mech 1981). Average litter size is a useful index of population productivity that is a function of the proportion of Wolves that breed, in turn a function of age structure, pack size, and number of packs relative to lone Wolves (Fuller 1989). Age structure may influence productivity, because most wild female Wolves do not breed until two or three years of age, and many probably not until four or five years of age (Mech 1991). Pack size determines number of females and helpers in a pack and has been correlated with productivity (Harrington et al. 1983).

Maximum observed litter size during the 21 years suggested that productivity of Wolves in Greenland under optimal conditions was limited to three pups. Mean maximum litter size from 17 studies employing similar methods was 7.1 pups/litter (Table 2). Thus, available data suggested that mean maximum productivity of Wolves in Greenland was 58% below that reported by the studies referenced in Table 2.

Litter size data from packs elsewhere in the High Arctic observed in mid-summer showed that a maximum litter size of 10 pups was observed in the Canadian Arctic Archipelago, although Miller (1978) stated that 11 pups were seen in one litter on southwestern Melville Island. This unusual observation may have represented > one litter similar to four sightings of 11-12 pups, representing two litters in Denali Park, Alaska (Mech et al. 1998). Multiple litters in one Wolf pack have not been reported sighted in Greenland and are likely exceptionally rare, if they occur at all, given the low prey density and small pack sizes.

The most likely reason for low litter sizes in Greenland was related to prey availability and vulnerability. Overall density of Muskox (*Ovibos moschatus*) in the study region was 5.3 Muskoxen/100 km² assuming a midpoint estimate of 10918 Muskoxen (Boertmann and Forchhammer 1992*; Boertmann et al. 1992). This was extraordinarily low biomass relative to lower latitudes (see Marquard-Petersen in press for comparative analysis), and was noteworthy because Wolves inhabiting regions of low prey density have lower success in reproduction (Messier 1985). For example, a study of 155 Wolves from Alaska concluded that (1) in utero litter sizes declined with declining prey availability per Wolf, (2) more females reproduced when per capita ungulate biomass was moderate to high, and (3) suppression of estrus occurred at very low prey availability (Boertje and Stephenson 1992). Results of a study of productivity of tundra Wolves in the Keewatin District, Northwest Territories, suggested that reproduction was positively correlated with availability of prey (Hillis 1990*). Furthermore, mean productivity in Wolves

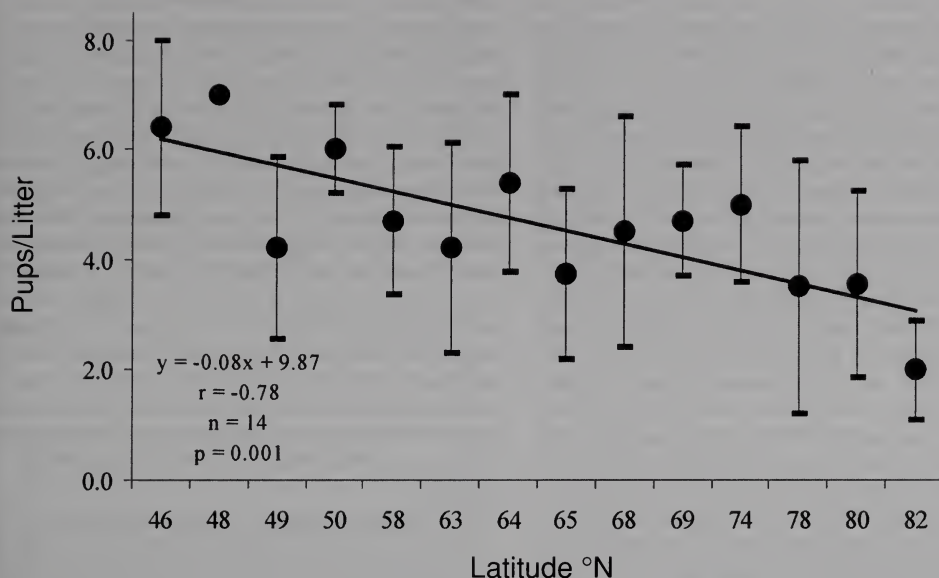


FIGURE 2. Average litter size and standard deviation of Wolves in North America relative to increasing latitude determined by sightings of pups in summer. From references in Table 2.

apparently declines with increasing latitude (Figure 2), perhaps because there are fewer prey species available to Wolves in the High Arctic than in lower latitudes, as the number of species per unit area decreases with increasing latitude (Pagel et al. 1991). Also, large ungulate prey in the High Arctic is scattered over vast areas in a limited and clumped distribution due to complex topography (Tener 1963; Thing et al. 1987; Miller 1993*; Aastrup 2000*). This fact would adversely affect the ability of Wolves to locate their prey. Thus, low food availability offered the most plausible explanation for the small average litter sizes reported here. It was noteworthy that the three sightings of single pups in North Greenland were made in areas known to support the lowest densities of Muskoxen.

Other causes believed to be responsible for small litter sizes in Wolves include diseases, such as canine parvovirus or infectious canine hepatitis (Boyd and Jimenez 1994), and inbreeding depression (Laikre and Ryman 1991). There was no evidence that any of these factors were important in my study region.

Larger packs in Greenland were producing more pups than smaller packs. Surviving litter size has been correlated with pack size (Harrington et al. 1983), although some researchers found no evidence of this relationship (Pletscher et al. 1997). Larger packs kill more ungulate prey than smaller packs but have less food available per pack member than smaller packs (Fritts and Mech 1981; Messier and Crête 1985; Ballard et al. 1987; Messier 1987; Thurber and Peterson 1993; Dale et al. 1995). Pack members ("auxiliaries")

help feed the pups in larger packs thereby increasing pup survival (Brainerd et al. 2008). Pack size and litter size in an increasing Wolf population with abundant prey in Minnesota were positively correlated, and litter size in a declining population at low prey density was inversely related to pack size (Harrington et al. 1983). Availability of food influenced ability or willingness of subordinate Wolves to provide food for pups, thus affecting pup survival (Harrington et al. 1983). Both ecological conditions are relevant to the present study, because the Wolf population in Greenland was expanding during the years following its documented reoccurrence (1978) until about 1992 followed by a decline or leveling off during the mid-1990s (Marquard-Petersen 2007*). More post-1993 sightings of pups were needed to investigate whether the inverse relationship between litter size and pack size observed in Minnesota also occurred in Greenland. Wolf pairs in a declining population in Minnesota produced more surviving pups than larger packs (Harrington et al. 1983). Therefore, Wolf pairs in northeast Greenland that produced fewer pups than larger packs may have experienced higher survival rates, and the smaller litter sizes may represent an adaptation to this extreme environment.

Frequency of Reproduction

A minimum of 22 pups were produced in the study region between 1985 and 1997. That refuted a claim by Maagaard and Graugaard (1994) that most Greenland Wolves originated from Ellesmere Island and that very few were born in Greenland. Because of paucity of data from the vast study region, firm conclusions

pertaining to frequency of pup production could not be reached. Nevertheless, some conjecture was possible based upon the Hold with Hope data. Wolves were first sighted in this area in March 1980, but no signs of reproduction were detected until July 1988 (Turner and Dennis 1989) despite expeditions during at least 6 of 10 years, 1978-1987, and a yearly average of 836 linear km (SD 203 km) by military sled patrols that patrol the area during winter between January 1980 and June 1988. This did not establish that reproduction did not occur, but simply reflected that no evidence was reported. Pack size during this period apparently never exceeded two Wolves (Marquard-Petersen 2007*). Then, pups were sighted in Hold with Hope in 1988, 1990, 1992, and 1995, and circumstantial evidence suggested reproduction in 1991 (Marquard-Petersen 1994). These facts indicated that Wolves in this particular area produced two or three pups every second or third year during a favorable period from 1988-1992. During other years, 1989, and 1996-1998, it appeared no pups were produced in Hold with Hope as evidenced by absence of fresh diggings at known den sites (cf. Mech 1995) or a low track density. The latter was more revealing than the former, because a single field investigator working in an area only every other year can seldom be certain that all dens were detected. There were no indications that pups were produced in other years or in nearby areas, including Hudson Land and Gauss Peninsula, or that denning conditions (soil, prey availability) were as favorable there.

If an argument is made that these observations were valid for the study region at large and over larger time periods, then pup production appeared to be irregular even under the most favorable circumstances, because Hold with Hope supported the second-largest Muskox population in East Greenland (Boertmann and Forchhammer 1992*). This ungulate availability was supplemented by thousands of geese in summer (Marquard-Petersen 1998). The area was also home to the largest known, contemporary pack size in Greenland of nine Wolves. Frequency of reproduction was almost certainly lower in more marginal areas, such as Germania Land and southern Kronprins Christian Land. If reproduction were irregular, it would support what was known about pup production on the Canadian Arctic Islands where some years were characterized by an absence of pups (Miller and Reintjes 1995). For example, on the western and central Queen Elizabeth Islands, pups were seen in only one of seven surveys (Miller 1993*). No causal relationship has been established, but Mech (2005) produced data from Ellesmere Island indicating that a six-year absence of Wolf reproduction in one area was the consequence of a decline in Muskoxen and Arctic Hares (*Lepus arcticus*) due to two snowy summers in four years.

A long reproductive interval and low rate of production of offspring have been reported in other species of arctic mammals, e.g., Polar Bears (*Ursus maritimus*)

in the Beaufort Sea (Amstrup 1995*). Muskox in north-east Greenland probably produce one calf every 2-3 years (Aastrup et al. 1986*; Thing et al. 1987). Adamczewski et al. (1997) noted that "...annual calving [in muskoxen] occurs only under very good conditions in the wild..." Such low reproductive rates are likely a consequence of low availability of forage, because there is a general trend of decreasing productivity with increasing latitude (Crête and Manseau 1996). For example, Tener (1965) stated that Muskox range near Lake Hazen, northern Ellesmere Island, produced $\frac{1}{4}$ to $\frac{1}{4}$ of forage produced on herbivore range in Jasper and Banff National Parks to the south and on the prairie ranges. The frequency of pup production among Wolves and other canids in lower latitudes is generally much higher. Wolves typically have one litter per pack annually (see Peterson et al. 1984; Ballard et al. 1987; Bjorge and Gunson 1989; Mech 1991; Mech et al. 1998).

Mortality

Without radiotelemetry, it is very difficult to evaluate the predominant causes of deaths in extant Wolf populations (Carbyn 1975*). Accordingly, numerous researchers in more accessible areas have reported small sample sizes that made definitive conclusions difficult (Mech 1977 ($n = 24$); Ream et al. 1991 ($n = 12$); Licht and Fritts 1994 ($n = 10$); Anthony 1997 ($n = 24$); Wabakken et al. 2001 ($n = 26$); Kamler et al. 2003 ($n = 12$)). Such limited information should not be disregarded, because sample sizes as small as 10 can give results useful for characterization of populations (Hayek and Buzas 1997). In fact, "in many, if not most, field surveys a small amount of data is all that can be obtained" (Hayek and Buzas 1997, also noted as a problem by Ballard et al. 1997; Creel 1997; Morrison et al. 1998).

My study undoubtedly identified only a fraction of the Wolves that died in the study region during the 21 years. Similar difficulties have been reported by other researchers; e.g., Peterson et al. (1998) who noted that >90% of Wolf mortality in their area could not be explained. Nevertheless, it was noteworthy that four of the eight Wolves known to have died were killed by humans inside the Northeast Greenland National Park, where Wolves were legally protected year-round. Events leading up to three of these killings followed a typical pattern. Firstly, people coaxed the particular Wolf or its mate to come closer for photo opportunities by offering them food scraps. Secondly, eventually three of the four Wolves became accustomed to frequenting station areas for extended periods. Wolves then became bolder and began engaging in behavior considered a nuisance by station personnel (e.g., fighting with tethered sled dogs, stealing food from dogs, howling at night keeping personnel awake, scavenging on refuse, raiding the nests of waterfowl nesting on the station area, etc.). Similar nuisance behaviors by Wolves related to garbage and domestic dogs were reported from Ellesmere Island (Grace 1976; Miller 1978; Gray

1995*). Thirdly, as the perception of a Wolf changed from a valued photo opportunity to a nuisance, efforts were made to chase it away, typically by shooting aerial flares at it. These efforts were universally fruitless, as Wolves quickly learned that such events were harmless. Finally, shots were fired directly at the animal. Three of four Wolves killed by humans inside the national park were shot after conflicts with domestic dogs, demonstrating that the presence of sled dogs in northeast Greenland created an environment with an increased potential for conflicts that in some cases were deleterious to Wolves.

It was unknown how much such killings contributed to overall mortality, because sample size was low, and the data were biased towards inflation of the proportion of human-caused deaths. Such mortality was probably not important at the regional population level, but could be important locally in areas where litter sizes consisted of a single pup, or during times when the population was declining and pup survival was low. Furthermore, the loss of relatively few adult females could have a disproportionately large, adverse effect upon population size in local areas as well as regionally, if the loss occurred in a core Wolf area. Feeding of wildlife in the national park in northeast Greenland was illegal, but was practiced and enforcement was non-existent. No charges were brought to bear against individuals who killed Wolves illegally inside the national park (i.e., not in self-defense). Such killings were generally kept quiet, and details were not readily forthcoming.

In areas outside the High Arctic, the major cause of mortality of species inhabiting protected areas is conflict with people in border areas that become population sinks (Woodroffe and Ginsberg 1998). Four of six Wolves killed by humans in my study region were shot on base areas, suggesting that military or civilian stations constituted periodic population sinks. Although such killings were rare, weather stations, airports, military bases, and field camps may have a measurable, cumulative adverse effect on the small, disjunct Wolf population in the region. Given the apparent extraordinarily low density of Wolves in northeast Greenland (Marquard-Petersen in press), even the occasional killing of one or two Wolves by humans could have a substantial adverse effect by wiping out a disproportionately high percentage of a local population; e.g., in an area occupied by a single Wolf pair. This adverse effect would be exacerbated by the fact that such mortality not necessarily would be counteracted by recruitment from nearby packs given the likely low reproductive rate, insular characteristics of Wolf distribution, and likely low immigration rates into some areas (see Marquard-Petersen in press).

Data were biased, because Wolves killed by humans were more likely to be reported than Wolves that died of natural causes. Thus, mortality from sources known to be important in other populations was poorly represented; e.g., intraspecific strife and malnutrition. In

northeastern Minnesota, intraspecific strife was the primary cause of mortality of adult Wolves (Mech 1977). In Denali Park, Alaska, 39% of known mortality was conspecific (Mech et al. 1998). In central East Greenland, a young sled dog that had become separated from other sled dogs in November 1998 was attacked and killed by a pack of four Wolves, suggesting that intraspecific strife may be equally important in this population. Packs elsewhere often chase and occasionally kill lone Wolves found trespassing in their territory (Peterson et al. 1998). Mortality from malnutrition may be common in my study region, because: (1) some Wolves probably inhabit areas of low relative prey density, (2) the proportion of loners was high (Marquard-Petersen in press), and (3) it may be difficult for lone Wolves to kill Muskoxen (cf. Gray 1970; Miller and Gunn 1977). Wolves in a low prey area in Quebec suffered higher mortality from starvation and intraspecific aggression than Wolves in a high-prey area (Messier 1985). There were few comparable data from the High Arctic. Inuit on the Canadian Arctic Archipelago represented the greatest cause of Wolf mortality in that region with some cases of entire packs being wiped out (Miller 1993*).

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Les collisions d'oiseaux à l'édifice Marly à Sainte-Foy, Québec, de 1978 à 2007

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Since its construction in 1978, thousands of birds have been killed following collisions on the Marly mirror-glassed building located in the western area of Quebec City. This paper presents ornithological observations and describes the collision phenomenon at this site. Data show that the number of birds killed by collisions has declined dramatically over the 30-year period. Probable causes of this decline are discussed.

Key Words: bird-window collisions, fatalities, building, decline, population, habitat, Quebec.

Mot-clés: oiseaux, collisions, édifice, vitre-miroir, mortalité, population, déclin, habitat, Québec.

Les collisions d'oiseaux contre des constructions humaines causent chaque année la mort de millions d'oiseaux en Amérique du Nord. Certains spécialistes estiment ce nombre à près d'un milliard (Klem 1990; Dunn 1993; Doeker 2005*). Ces collisions s'expliquent de différentes façons:

(A) Structures éclairées la nuit (édifices, tours de télécommunication, ponts, etc.): les oiseaux sont attirés et éblouis par la lumière;

(B) Structures hautes: placées sur leur route, les oiseaux s'y frappent par temps de mauvaise visibilité;

(C) Verre transparent: les oiseaux ne voient pas les parois vitrées et s'y heurtent;

(D) Verre réfléchissant: l'environnement se refléchit dans la vitre. Lorsque la vitre est de type miroir, l'effet est parfait. L'oiseau vole allègrement vers l'image de son environnement et se cogne contre la vitre;

(E) L'oiseau voit son image dans une vitre miroir. S'il est un mâle en période de reproduction, il fonce *illico* sur l'intrus "mâle virtuel" pour défendre son territoire et frappe le verre.

Au printemps 1978, l'auteur travaille sur le chantier de construction de l'édifice Marly de Sainte-Foy située à 4 km à l'ouest du pont de Québec. Chaque jour avant et après le travail, les oiseaux qui se sont tués en se frappant contre les vitres miroir de l'édifice sont ramassés. Le nombre et les espèces d'oiseaux recueillis à cette époque, ainsi qu'au cours d'autres visites effectuées par la suite sur les lieux, sont résumés dans cet article.

Aire d'étude et Méthodologie

Dans les années 1970, l'ensemble du secteur était occupé par une forêt naturelle composée de plusieurs associations matures, notamment une érablière à érable à sucre (*Acer saccharum*), une chênaie rouge (*Quercus ruber*), une frênaie (*Fraxinus* spp.) et une hêtraie (*Fagus gradifolia*). Situé dans un corridor mig-

ratoire (fleuve Saint-Laurent/rivière Cap-Rouge), ce milieu forestier dénommé boisé Marly, regorgeait d'oiseaux, en particulier à l'automne et au printemps (Reginald Ouellet, communication personnelle: Notes de rencontres du 23 août 2000 et du 17 novembre 2006). Cette forêt, d'une superficie d'environ 250 hectares à l'époque, est maintenant fragmentée par l'urbanisation.

La construction de l'édifice Marly débute en 1976 et se termine en 1979. L'édifice est entièrement recouvert de vitres miroir dorées (pellicule d'or) dans son pourtour, créant une surface réfléchissante d'environ 14000 mètres carrés. Le boisé se trouve à plus de 100 mètres de l'édifice à l'exception du côté nord-est où il se trouve à moins de 10 mètres.

L'étude repose sur une série d'observations ponctuelles effectuées au cours de visites des lieux au printemps et à l'automne entre 1978 et 2007. Ces visites, au nombre de 148, consistaient à marcher le long des façades de l'édifice, à ramasser les oiseaux trouvés morts et à les placer dans des sacs pour être identifiés le soir même. Les visites comportaient des périodes d'observations d'une durée variant entre 5 et 95 minutes, pour un total de 3045 minutes. Les informations suivantes étaient consignées: nombre, espèce, sexe (lorsque le dimorphisme le permettait), durée d'observation, date et endroit de cueillette (orientation de la façade).

Résultats

Dans l'ensemble, un total de 181 oiseaux représentant 38 espèces ont été trouvés et répertoriés (voir annexe). L'importance relative des différents groupes d'oiseaux les plus affectés par les collisions est présentée au Tableau 1.

Les collisions observées contre l'édifice Marly correspondent majoritairement à la situation "D" décrite en introduction. Des cas de comportement d'attaque

TABLEAU 1. Oiseaux victimes de collision à l'édifice Marly, 1978-2007 ($n = 181$)

Groupe d'espèces	Printemps	Automne	Total
Parulines (warblers)	63,6 %	26,1 %	39,8 %
Juncos (juncos)	1,5 %	22,6 %	14,9 %
Gros-becs et cardinals (grosbeaks & cardinals)	6,1 %	17,4 %	13,3 %
Grives (thrushes)	21,2 %	6,9 %	12,2 %
Roitelets (kinglets)	0 %	13,0 %	8,3 %
Bruants (buntings)	1,5 %	8,7 %	6,1 %
Pics et grimpereaux (woodpeckers & creepers)	1,5 %	2,6 %	2,2 %
Mésanges (chickadees)	0 %	2,6 %	1,6 %
Quiscales (grackles)	3,0 %	0 %	1,1 %
Viréos (vireos)	1,5 %	0 %	0,5 %

d'un mâle contre son image miroir (situation "E") ont également été observés à quelques reprises. Les oiseaux qui se heurtent ne constituent pas nécessairement un portrait représentatif de l'avifaune du boisé, mais reflètent d'abord les espèces qui ont une propension à se cogner dans les vitres pour des raisons comportementales. Le secteur abrite plusieurs espèces qui ne se cognent jamais ou très rarement, notamment celles qui suivent qui ont été observées de temps à autres dans le boisé:

- Colibri à gorge rubis (*Archilochus colubris*)
- Corneille d'amérique (*Corvus brachyrhynchos*)
- Etourneau sansonnet (*Sturnus vulgaris*)
- Geai bleu (*Cyanocitta cristata*)
- Hirondelle bicolore (*Tachycineta bicolor*)
- Jaseur d'amérique (*Bombycilla cedrorum*)
- Merle d'amérique (*Turdus migratorius*)
- Mésange à tête noire (*Poecile atricapillus*)
- Moineau domestique (*Passer domesticus*)
- Pic flambloyant (*Caolaptes auratus*)
- Sittelle à poitrine blanche (*Sitta carolinensis*)
- Tyran huppé (*Myiarchus crinitus*)

Les parulines représentent le principal groupe de victimes des collisions (39,8 %). Elles sont proportionnellement plus affectées au printemps (63,6 %) qu'à l'automne (26,1 %). La grande majorité des oiseaux (> 90 %) se cognent contre la façade située au nord-est et ce, autant au printemps qu'à l'automne (données non-présentées). C'est à cet endroit que la forêt se trouve le plus près de l'édifice (environ 10 mètres), et que les arbres et les oiseaux se reflètent pleinement dans les vitres miroir. Les oiseaux qui se cognent semblent être majoritairement des mâles, du moins au printemps (23 mâles, 3 femelles et 18 inconnus).

Chacune des espèces observées se trouve dans son aire de nidification. Les oiseaux observés au printemps sont donc des nicheurs potentiels. Certains indices laissent cependant croire qu'il s'agit d'oiseaux de passage puisque la plupart des collisions a lieu durant les périodes de migration.

Le nombre de collisions a diminué radicalement depuis 30 ans. Par exemple, le nombre moyen d'oiseaux trouvés morts par visite est de 2,6 (42 individus, 16 visites) en mai 1978 alors qu'il est de 0,82 (9 indi-

vidus, 11 visites) en mai 2000 et de 0,25 (1 individu, 4 visites) en mai 2007 (basée sur les données de l'annexe). Il est estimé que le taux de collisions a diminué d'un facteur 10 à 30 depuis les observations de 1978 et de 1980. Cette baisse radicale du taux de collisions suggère un déclin important de la population locale de passereaux. D'autres facteurs que les collisions doivent également être considérés pour expliquer cette baisse, notamment:

- l'effritement de l'habitat forestier dans ce secteur au profit de l'urbanisation;
- l'apprentissage et l'habitation des oiseaux à la présence des vitres miroir;
- un changement du corridor de migration des espèces concernées dans ce secteur;
- l'utilisation de pesticides en milieu urbain et péri-urbain (la plupart des espèces affectées sont des insectivores);
- une population de prédateurs nécrophages qui s'est probablement développée autour de l'édifice; les oiseaux morts étant ramassés rapidement, ils ne peuvent être répertoriés.

Le phénomène de prédation des oiseaux morts par des nécrophages a été observé indirectement à quelques reprises. Par exemple, des corneilles ont été vues avec des oiseaux dans le bec. Cependant, des observations prolongées (données non présentées) montrent que ce phénomène ne peut à lui seul expliquer la baisse de collisions.

Discussion

Les données obtenues témoignent de l'abondance (fréquence élevée de collisions) et de la diversité des espèces (50 espèces courantes) qui fréquentaient le boisé il y a plus de 25 ans (voir liste en annexe). On y retrouvait des espèces relativement rares (ex. paruline à ailes dorées), des espèces typiques de forêts matures (ex. paruline à poitrine baie), des espèces de jeunes forêts (ex. paruline à flanc marron), de forêts de conifères (ex. paruline tigrée), de feuillus (ex. grive des bois) ou de milieux semi-ouverts (ex. junco ardoisé). L'absence de données entre 1980 et 2000 ne permet pas de déterminer à quel rythme le déclin s'est effectué. Basée sur certaines suppositions, les calculs (non

présentés ici par manque d'espace) montrent que le nombre d'oiseaux qui ont péri contre les vitres de l'édifice s'élève à plus de 5000.

La contribution respective des collisions au déclin des espèces étudiées est difficile à établir avec précision. Les données sont toutefois claires sur un aspect: le nombre et la biodiversité des oiseaux fréquentant ce milieu ont chuté significativement depuis 30 ans. Les observations effectuées (non présentées) au cours des dernières années dans le boisé à proximité montrent que celui-ci est occupé aujourd'hui surtout par des espèces ubiquistes ou représentatives de milieux dégradés comme les mésanges, sansonnets, corneilles et moineaux. Le déclin observé ne peut être attribué directement à une tendance générale dans la province ou au Canada car les inventaires d'oiseaux nicheurs (Downes et Collins 2003) montrent que les populations des espèces étudiées dans ce texte n'ont pas diminuées de façon marquée au cours des 3 à 4 dernières décennies.

Conclusion

Les observations d'oiseaux à l'édifice Marly représentent un exemple tangible de changements notables qui s'opèrent subrepticement dans notre environnement et ce, à l'intérieur de quelques années. Les données de 2006-2007 montrent que malgré un taux de collision relativement très bas, il se tue encore une centaine d'oiseaux par année. La grande majorité des oiseaux morts depuis 1978 a été retrouvée le long de

la façade du côté nord-est, là où des arbres se trouvent situés tous près du mur vitré. Une solution simple au problème de collisions à l'édifice Marly aurait été de couper ces quelques arbres. Il y en aurait moins d'une dizaine à enlever.

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ANNEXE: Liste des oiseaux trouvés morts au bas des murs vitrés de l'édifice Marly lors de visites effectuées entre 1978 et 2007

Année	Date	Espèce	Nom scientifique	Sexe	Nombre	Endroit
1978	18 mai	Junco ardoisé	<i>Junco hyemalis</i>	M	1	Sud-est
		Paruline couronnée	<i>Seiurus aurocapilla</i>	M	1	Nord-est
	21 mai	Grive à dos olive	<i>Catharus ustulatus</i>		4	Nord-est
	22 mai	Paruline obscure*	<i>Vermivora peregrina</i>	M	1	Nord-est
	23 mai	Paruline obscure	<i>Vermivora peregrina</i>	M	2	Nord-est
	24 mai	Paruline obscure	<i>Vermivora peregrina</i>	M	4	Nord-est
	25 mai	Cardinal à poitrine rose	<i>Pheucticus ludovicianus</i>	M	2	Sud-est
		Paruline tigrée	<i>Dendroica tigrina</i>	M	1	Nord-est
		Paruline obscure	<i>Vermivora peregrina</i>	M	5	Nord-est
	26 mai	Paruline obscure	<i>Vermivora peregrina</i>	M	3	Nord-est
		Paruline à tête cendrée	<i>Dendroica magnolia</i>		1	Nord-est
	29 mai	Paruline à calotte noire	<i>Wilsonia pusilla</i>		1	Nord-est
		Paruline couronnée	<i>Seiurus aurocapilla</i>	M	1	Nord-est
		Paruline du Canada	<i>Wilsonia canadensis</i>	F	2	Nord-est
		Paruline obscure	<i>Vermivora peregrina</i>	M	2	Nord-est
		Gros-bec errant	<i>Coccothraustes vespertinus</i>	F	1	
		Paruline rayée	<i>Dendroica striata</i>	M	2	
		Grive à dos olive	<i>Catharus ustulatus</i>		6	
	30, 31 mai	Paruline à poitrine baie	<i>Dendroica castanea</i>	F	2	
		Aucun				
	1 juin	Grive à dos olive	<i>Catharus ustulatus</i>		1	
	2 juin	Aucun				
	5 juin	Paruline à gorge orangée	<i>Dendroica fusca</i>	M	1	Nord-est
		Grive à dos olive	<i>Catharus ustulata</i>		1	
	6 juin	Aucun				
	7 juin	Paruline triste	<i>Oporornis philadelphia</i>	M	1	Nord-est

ANNEXE: (suite)

Année	Date	Espèce	Nom scientifique	Sexe	Nombre	Endroit
	9 juin	Aucun				
	12 juin	Paruline à gorge orangée	<i>Dendroica fusca</i>	M	1	Nord-est
	13, 15 juin	Aucun				
	16 juin	Cardinal à poitrine rose	<i>Pheucticus ludovicianus</i>	M	1	Nord-est
		Viréo aux yeux rouges	<i>Vireo olivaceus</i>		1	Nord-est
	19 juin	Grive des bois	<i>Hylocichla mustelina</i>		1	Sud-est
	23, 29 juin	Aucun				
	1 juil.	Grive	<i>Catharus sp.</i>		1	
		Bruant			1	
	3 juillet	Paruline jaune	<i>Dendroica petechia</i>	M	1	Nord-est
	5 juillet	Aucun				
	6 juillet	Quiscale bronzé	<i>Quiscalus quiscula</i>		1	Nord-est
	7 juillet	Aucun				
	10 juillet	Pic flamboyant	<i>Colaptes auratus</i>		1	
		Quiscale bronzé	<i>Quiscalus quiscula</i>		1	Nord-est
	11 juillet	Paruline obscure	<i>Vermivora peregrina</i>		1	Nord-est
1980						
	15 septembre	Paruline à joues grises	<i>Vermivora ruficapilla</i>		2	Nord-est
		Paruline à gorge noire	<i>Dendroica virens</i>		1	Nord-est
		Paruline à ailes dorées	<i>Vermivora chrysoptera</i>	M	1	Nord-est
		Pic à dos noir	<i>Picoides arcticus</i>	F	1	Nord
		Roitelet à couronne dorée	<i>Regulus satrapa</i>	F	1	Nord-est
	20 septembre	Paruline obscure	<i>Vermivora peregrina</i>		2	Nord-est
		Paruline à collier	<i>Parula americana</i>	F	1	Nord-est
		Paruline des ruisseaux	<i>Seiurus noveboracensis</i>		1	Nord-est
		Paruline à joues grises	<i>Vermivora ruficapilla</i>		2	Nord-est
		Junco ardoisé	<i>Junco hyemalis</i>		3	Sud-est
		Gros-bec errant	<i>Coccothraustes vespertinus</i>		1	Nord-est
		Bruant à gorge blanche	<i>Zonotrichia albicollis</i>	M	3	Nord-est
		Grive solitaire	<i>Catharus guttatus</i>		1	Nord-est
		Grive à dos olive	<i>Catharus ustulatus</i>		1	Nord-est
		Mésange à tête noire	<i>Parus atricapillus</i>		2	Nord-est
		Roitelet à couronne dorée	<i>Regulus satrapa</i>	M	1	Nord-est
	8, 9 10, 14, 15 octobre	Junco ardoisé	<i>Junco hyemalis</i>		21	#
	(Rosa, 1980)	Gros bec errant	<i>Coccothraustes vespertinus</i>		18	#
		Roitelet à couronne dorée	<i>Regulus satrapa</i>		7	#
		Paruline à joues grises	<i>Vermivora ruficapilla</i>		5	#
		Paruline			4	#
		Paruline à croupion jaune	<i>Coccothraustes vespertinus</i>		3	#
		Bruant hudsonien	<i>Spizella arborea</i>		3	#
		Grive à dos olive	<i>Catharus ustulatus</i>		3	#
		Grive solitaire	<i>Catharus guttatus</i>		2	#
		Roitelet à couronne rubis	<i>Regulus calendulus</i>		1	#
		Paruline bleue	<i>Dendroica caerulescens</i>		1	#
		Paruline masquée	<i>Geothlypis trichas</i>		1	#
		Paruline à calotte noire	<i>Wilsonia pusilla</i>		1	#
		Cardinal à poitrine rose	<i>Pheucticus ludovicianus</i>		1	#
		Mésange à tête noire	<i>Poecile atricapillus</i>		1	#
		Bruant à gorge blanche	<i>Zonotrichia albicollis</i>		1	#
2000						
	13 mai	Paruline triste*	<i>Oporornis philadelphia</i>	M	2	Nord-est
		Paruline à flancs marron	<i>Dendroica pensylvanica</i>	M	1	Nord-est
	14 mai	Paruline à flancs marron	<i>Dendroica pensylvanica</i>	M	1	Nord-est
		Paruline (tête mangée)			1	
	15, 16, 17, 19, 21 mai	Aucun				
	22 mai	Paruline à croupion jaune	<i>Coccothraustes vespertinus</i>	M	1	Nord-est
		Paruline à tête cendrée	<i>Dendroica magnolia</i>	M	1	Nord-est
	27 mai	Aucun				
	28 mai	Paruline à flancs marron	<i>Dendroica pensylvanica</i>	M	1	Nord-est
	30 mai	Viréo aux yeux rouges	<i>Vireo olivaceus</i>		1	Nord-est
	3, 4, 11, 17, 18 juin	Aucun				

ANNEXE: (fin)

Année	Date	Espèce	Nom scientifique	Sexe	Nombre	Endroit
2008	20, 22 août	Aucun				
	11 octobre	Aucun				
	12 octobre	Grive solitaire*	<i>Catharus guttatus</i>		1	
		Bruant			1	
		Bruant chanteur	<i>Melospiza melodia</i>		1	
2001	13, 16, 22 octobre	Aucun				
	21 mai	Aucun				
	4 septembre	Aucun				
2003	8 octobre	Aucun				
	8 novembre	Pic chevelu	<i>Picoides villosus</i>		1	Nord-est
2006	20, 22 septembre	Aucun				
	25 septembre	Paruline à croupion jaune*	<i>Coccothraustes vespertinus</i>		1	Nord-est
	27 septembre	Paruline à joues grises	<i>Vermivora ruficapilla</i>		1	Nord-est
	28 septembre	Paruline obscure	<i>Vermivora peregrina</i>		1	Nord-est
	2 octobre	Aucun				
	3 octobre	Roitelet à couronne rubis	<i>Regulus calendula</i>		1	Nord-est
	4, 5, 10 octobre	Aucun				
	11 octobre	Roitelet à couronne dorée	<i>Regulus satrapa</i>	M	1	Nord-est
	12, 13, 14, 15 octobre	Aucun				
	16 octobre	Grimpereau brun	<i>Certhia americana</i>		1	Nord-est
	17, 18, 24, 25 octobre	Aucun				
2007	20 avril	Aucun				
	17 mai	Aucun				
	21 mai	Paruline				
		Paruline à croupion jaune*	<i>Coccothraustes vespertinus</i>	M	1	Nord-est
	26,27 mai	Aucun				
	9 juin	Aucun				
	1 septembre	Aucun				
	2, 5, 6, 8, 10, 13 octobre	Aucun				
	14 octobre	Roitelet à couronne rubis	<i>Regulus calendula</i>	M	1	Sud-est
	15, 16, octobre	Aucun				
	17 octobre	Junco ardoisé	<i>Junco hyemalis</i>	M	2	Nord-est
		Bruant*			1	Nord-est
	18 octobre	Aucun				
	19 octobre	Roitelet à couronne rubis*	<i>Regulus calendula</i>	F	2	Nord-est
	23, 25, 27 octobre	Aucun				

*Assommée seulement, a repris son envol

Façade nord-est à 92 %

TOTAL:

181

A Localized Decline in the Western Chorus Frog, *Pseudacris triseriata*, in Eastern Ontario

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Sebourn, David C., Carolyn N. L. Sebourn, and Wayne F. Weller. 2008. A localized decline in the Western Chorus Frog, *Pseudacris triseriata*, in eastern Ontario. *Canadian Field-Naturalist* 122(2): 158–161.

To assess whether Western Chorus Frogs have declined in eastern Ontario, we conducted amphibian call surveys at 18 sites in the Cornwall area, where they were heard calling in 1990, as well as selected wetlands in the same area. Chorus frogs were detected at only 1 of the 18 original locations during surveys in 2001 and 2007. When survey locations with and without Chorus Frogs were considered, the site occupancy rate declined from 58% in 1990, to only 12% in 2007. Chorus Frogs appear to have declined in this area of eastern Ontario which is adjacent to documented declines in western Québec and northern New York.

Key Words: Western Chorus Frog, *Pseudacris triseriata*, Boreal Chorus Frog, *Pseudacris maculata*, amphibian decline, Ontario.

The Western Chorus Frog (*Pseudacris triseriata*) is a small hyloid frog that occurs in the northcentral USA, southern Ontario and southwestern Québec (Conant and Collins 1998). An analysis of mitochondrial DNA has suggested that chorus frogs from eastern Ontario, adjacent Québec and northern New York should be assigned to the Boreal Chorus Frog (*P. maculata*), rather than the Western Chorus Frog (Lemmon et al. 2007). The presence of more than one mitochondrial lineage within an amphibian species is not uncommon (e.g., Austin et al. 2002). Therefore, the conclusion that eastern Ontario chorus frogs should be assigned to pure *P. maculata* may be premature.

A number of declines have been reported in the Western Chorus Frog. It was once considered common southeast of Montreal (Bleakney 1959), but now appears completely absent from the area (Daigle 1997) and is now extremely rare in Québec (Desroches and Rodrigue 2004). The Canadian and American Marsh Monitoring Program of the Great Lakes basin reported that the Western Chorus Frog was the only amphibian to decline significantly between 1995 and 1999 (Weeber and Vallianatos 2000) and it was one of four amphibian species to decline significantly from 1995 to 2004 (Crewe et al. 2006). A significant decline also occurred in northern New York (Gibbs et al. 2005). The Great Lakes/St. Lawrence – Canadian Shield population of Canada was designated threatened in April 2008 by the Committee on the Status of Endangered Wildlife in Canada, largely as a result of declines in Québec (COSEWIC 2008*).

To assess whether the Western Chorus Frog has declined in eastern Ontario, an area close to known declines in Québec and New York, we re-surveyed an area near Cornwall where it had been heard calling by

one of us (WFW) at 18 of 31 survey locations on the evening of 30 April 1990 (Oldham and Weller 2000*). A potential flaw in follow-up surveys is only surveying the locations where a species was detected in the past. By surveying only historic locations, the only kind of change that can be detected is a decline. The regular extinction and colonization of amphibian species at particular wetlands is not uncommon (e.g. Hecnar and M'Closkey 1996) so follow-up surveys are likely to detect some localized extinctions. To compensate for this, two kinds of surveys were conducted: (1) Follow-up surveys: auditory monitoring at all locations where chorus frogs were detected in 1990, and (2) Site occupancy surveys: auditory monitoring at other appropriate habitats within the study area. By combining both kinds of surveys it would be possible to detect a decline or an increase in the percentage sites with chorus frogs.

Study Area and Methods

The chorus frog sites were located in Stormont, Dundas and Glengarry County (Figure 1, Table 1). Surveys in 1990 ranged from Cardinal to Cornwall. Western Chorus Frogs were detected only north of Long Sault, so 10 auditory stations to the southwest of Long Sault (Cardinal to Morrisburg) were excluded from all analyses. Western Chorus Frogs were heard at 18 of 31 auditory stations surveyed 30 April from approximately 20:00 to 23:00 h. Stations were selected by driving slowly with all car windows rolled down and stopping for 1–2 minutes at all locations where any calling frogs were heard.

Auditory follow-up surveys of 1–2 minutes were undertaken at 17 of the 18 Western Chorus Frog locations on the evening of 23–24 April 2001 from approxi-

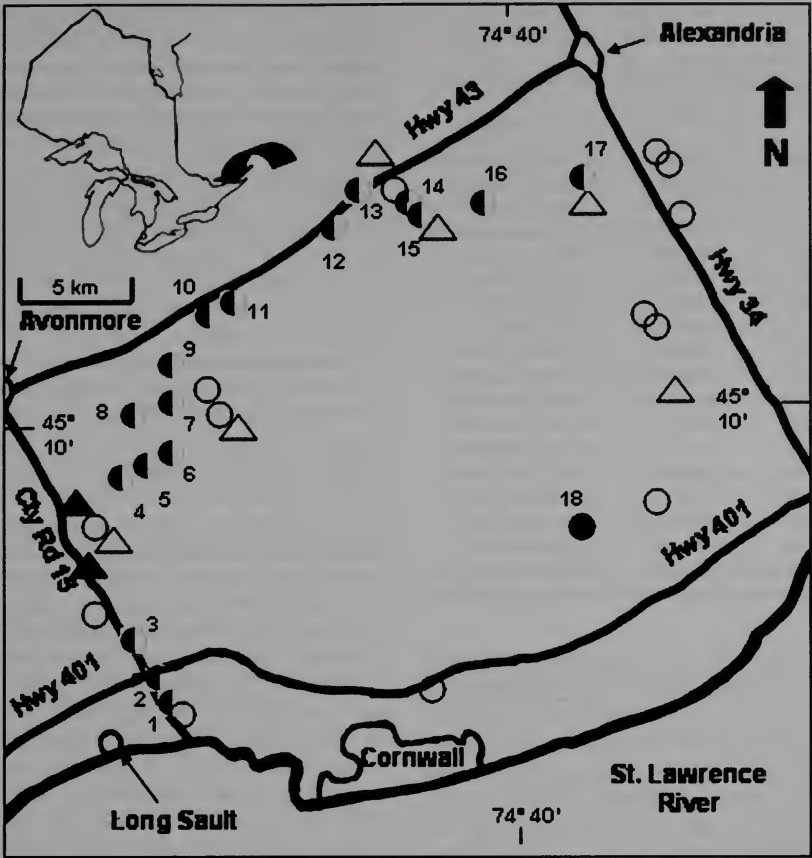


FIGURE 1. Survey locations for Western Chorus Frogs in eastern Ontario. Inset upper left is an outline of province of Ontario with arrow indicating study location. Circles represent original survey locations from 1990; solid: Chorus Frogs heard in 1990 and 2007; half-filled: Chorus Frogs heard in 1990, but not in 2001 or 2007; open: Chorus Frogs not heard in 1990. Triangles represent additional 2007 locations; solid: Chorus Frogs heard; open: Chorus Frogs not heard).

mately 20:00 to 01:30 h. A wetland with Western Chorus Frogs in Leeds and Grenville County was checked at the beginning and end of the survey to ensure Western Chorus Frogs were calling throughout the evening. The survey was repeated at all 18 chorus frog locations during the day on 20 April 2007, from approximately 10:00-18:00 h. The day was sunny with an air temperature above 10°C. A wetland with Western Chorus Frogs in Ottawa was checked before the survey to ensure chorus frogs were calling that day. Site occupancy surveys were also conducted in 2007 at an additional 8 wetlands along the survey route that were visible from the road (Figure 1).

Results

Follow up surveys

Western Chorus Frogs were heard calling at none of 17 of 18 original chorus frog locations surveyed in

2001 and only 1 of the 18 locations surveyed in 2007 (Figure 1, Table 2). The one location where Western Chorus Frogs were heard in 2007 was not surveyed in 2001.

Site occupancy surveys

Western Chorus Frogs were heard calling in 2007 at 2 of 8 additional wetlands surveyed (Figure 1). Both locations were north of site 3 along County Road 15 and approximately 2 km apart (45.0802°N, 74 74.8954°W and 45.0966°N, 74.9087°W). Overall, Western Chorus Frogs were detected at 58% of the 31 survey locations in this area in 1990, but only 12% of 26 locations in 2007.

Discussion

All sites with Western Chorus Frogs in 1990 were still present in 2001 and 2007, yet the species detected each year differed considerably (Table 2). The pres-

TABLE 1. Locations in Stormont, Dundas and Glengarry County where Western Chorus Frogs were heard calling on 30 April 1990, 20:00-23:00 h.

Site	Latitude (°N)	Longitude (°W)	Location
1	45.0438	74.8663	County Road 15
2	45.0555	74.8751	County Road 15
3	45.0672	74.8815	County Road 15
4	45.1059	74.8928	8 th Concession
5	45.1123	74.8699	8 th Concession
6	45.1167	74.8623	8 th Concession
7	45.1572	74.8609	Quail Road
8	45.1491	74.8800	Quail Road
9	45.1815	74.8736	Highway 138
10	45.2022	74.8595	County Road 43
11	45.2121	74.8379	County Road 43
12	45.2471	74.7715	County Road 43
13	45.2569	74.7562	County Road 43
14	45.2470	74.7346	Loch Gary Road
15	45.2434	74.7333	Loch Gary Road
16	45.2379	74.6964	Kenyon Road
17	45.2701	74.6388	Kenyon Road
18	45.0973	74.6399	Glen Road

ence of Gray Treefrogs (*Hyla versicolor*), the greater percentage of sites with American Toads (*Anaxyrus americanus*) and the lack of sites with Wood Frogs (*Lithobates sylvaticus*) in 1990 suggests that this survey took place relatively late in the anuran breeding season compared with the 2001 survey. Wood Frogs in particular are early breeders while Gray Treefrogs call relatively late in the spring breeding season. There were few sites with calling frogs in 2007 because the survey occurred during the day, when few species other than Western Chorus Frogs are consistently calling in eastern Ontario.

While it is possible that Western Chorus Frogs were still present at many of the Cornwall area sites but not calling during the follow-up surveys, this is unlikely for three reasons. First, we conducted two follow-up surveys, increasing the probability that Western Chorus Frogs would be detected if present. Second, surveys were conducted at optimal times, as Western Chorus Frogs were calling at known sites during both follow-up surveys. Third, when one of us (DCS) re-surveyed

historic locations from the Ontario Herpetofaunal Atlas database (Oldham and Weller 2000*) in rural west Ottawa when Western Chorus Frogs were known to be calling in 2007 and 2008, chorus frogs were detected at over 60% of the historic locations after just a single visit (DCS, unpublished data).

The detection of chorus frogs at two of the site occupancy survey sites demonstrates that chorus frogs are not completely absent from the western portion of the area. The pronounced decline in site occupancy rate from 58% in 1990 to only 12% in 2007 suggests chorus frogs are considerably less common across this area.

Localized declines in the Western Chorus Frog are not unusual. Daigle (1997) found that Western Chorus Frogs were absent southeast of Montreal but still widespread along the Ottawa River west of Hull, in Québec. Similarly, chorus frogs have declined in northern New York, but increased in west-central areas of the state (Gibbs et al. 2005). The recent phylogenetic analysis based on mitochondrial DNA suggesting that chorus frogs in eastern Ontario and adjacent Québec and northern New York should be assigned to the Boreal Chorus Frog rather than the Western Chorus Frog (Lemmon et al. 2007) offers another potential insight into some of the observed declines. If additional research supports this finding, then it would have been the Boreal Chorus Frog that declined in northern New York and the Western Chorus Frog that increased in distribution in west-central New York (Gibbs et al. 2005). It remains unclear why the "eastern" Boreal Chorus Frog may be more prone to decline and this should be a focus of future research.

Acknowledgments

We are indebted to Fred Schueler of the Bishops Mills Natural History Centre for first drawing our attention to the issue of chorus frog declines in eastern Ontario and for organizing the First Annual International Conference on Northeastern *Pseudacris triseriata* in March 2001. We are also grateful to Mike Oldham of the Natural Heritage Information Centre of the Ontario Ministry of Natural Resources for providing us with data from the Ontario Herpetofaunal Atlas. The manuscript benefited from comments from Francis Cook and three anonymous reviewers.

TABLE 2. Calling results from auditory surveys in Stormont, Dundas and Glengarry County from sites with Western Chorus Frogs in April 1990. Results by species indicate the number of sites with that species detected. Western Chorus Frog (*Pseudacris triseriata*), Spring Peeper (*P. crucifer*), Wood Frog (*Lithobates sylvaticus*), Northern Leopard Frog (*L. pipiens*), American Toad (*Anaxyrus americanus*), Gray Treefrog (*Hyla versicolor*).

Year	Number of sites	Species					
		Western Chorus Frog	Spring Peeper	Wood Frog	Northern Leopard Frog	American Toad	Gray Treefrog
1990	18	18	18	0	12	15	17
2001	17	0	17	13	9	8	0
2007	18	1	4	7	2	0	0

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Spatial and Temporal Differences in Giant Kidney Worm, *Dictophyma renale*, Prevalence in Minnesota Mink, *Mustela vison*

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Mech, L. David. 2008. Spatial and temporal differences in giant kidney worm, *Dictophyma renale*, prevalence in Minnesota Mink, *Mustela vison*. Canadian Field Naturalist 122(2): 162-165.

Examination of 110 Mink (*Mustela vison*) carcasses from 1998 through 2007 indicated that the giant kidney worm, *Dictophyma renale*, occurred in Pine and Kanabec Counties of eastern Minnesota with annual prevalences of 0-92%. Worm prevalence increased from 20% in 1999 to 92% in 2001 and decreased to 6% in 2005. During 2000 to 2007, no worms were found in Mink from Anoka and Chisago Counties (n = 54), and in 2000, none in 107 Mink from LeSeur, Freeborn, Redwood, Brown and Watonwan Counties. Changes in kidney worm prevalence were positively related to trapping success, considered an index of Mink density.

Key Words: Mink, *Mustela vison*, giant kidney worm, *Dictophyma renale*, *Lumbriculus variegatus*, Minnesota.

The giant kidney worm (*Dictophyma renale*) infects several species of carnivores in many areas of the world including the Mink (*Mustela vison*). The worm inhabits the right kidney of the Mink and destroys it. Studies of captive Mink infected with *D. renale* document that the worm can cause morbidity or mortality in that host (Graves 1937; Meyer and Whitter 1950; Mace and Anderson 1975). Reported prevalences of *D. renale* in Mink vary from 1 to 48% (Woodhead and McNeil 1939; Sealander 1943; Hallberg 1953; Schacher and Faust 1956; Miller and Harkema 1964; Crichton and Urban 1970; Fyvie 1971; Mace and Anderson 1975; Jorde 1980; Mech and Tracy 2001).

However no information is available about local kidney worm distribution in an area or about temporal changes in prevalence. Herein I provide new information about *D. renale* prevalences in Mink in various parts of eastern Minnesota and about temporal changes in prevalence.

Methods

I trapped Mink during the legal fur trapping season in 1998 to 2007 (except 2003) in counties of eastern Minnesota (Pine and Kanabec) where *D. renale* was known to exist (Mech and Tracy 2001) and in 2000, 2001 and 2004 to 2007, in counties where it was not known to exist (Anoka and southwestern Chisago). I also obtained 107 carcasses from trappers in five southern and southeastern Minnesota counties (Le Seur, Freeborn, Redwood, Brown, Wantowan) during 2000 where *D. renale* was not known to exist. I examined the kidneys and peritoneal cavities of the Mink carcasses for *D. renale*. I also compared my Mink trapping success between counties where *D. renale* was found with my success in the counties where I trapped and found no *D. renale*. I used the same trapping meth-

ods throughout the study area (Figure 1). I compared *D. renale* prevalences in the two areas by chi-square analysis.

Results

I captured 110 Mink in 6195 trap nights in Pine and Kanabec counties and 54 Mink in Anoka and southwestern Chisago counties during 2696 trap nights in 2000 to 2007 (Table 1). Although overall success rate was higher in the worm-free area (Table 1), the difference between the two study areas was not significant ($\chi^2 = 0.54$; $P = 0.46$; d.f. = 1). In the area known to harbor *D. renale* (Mech and Tracy 2001), annual *D. renale* prevalence varied from 0 to 92%, whereas in the area not known to harbor the parasite, the prevalence was 0% (Table 1). I found no *D. renale* in the 107 carcasses from the five southern and southwestern counties.

Annual kidney worm prevalence in Pine and Kanabec counties increased from 20% in 1999 to 92% in 2001 and then decreased to 6% in 2005 and remained low through 2007 (Figure 2). Trapping success was strongly correlated with worm prevalence in that study area ($r^2 = 0.72$, $P < 0.01$, Figure 3). Trapping success in the two study areas was weakly correlated ($r^2 = 0.49$, $P = 0.12$).

Discussion

My data indicate that the giant kidney worm (*D. renale*) did not exist or existed in very low prevalences in areas of eastern Minnesota south of about Wyoming, Minnesota (latitude 45°22'N.), in southwestern Chisago County during this study while its prevalence was high north of that area. These findings that *D. renale* range or prevalence in eastern Minnesota differs between north and south begs the question as to why this

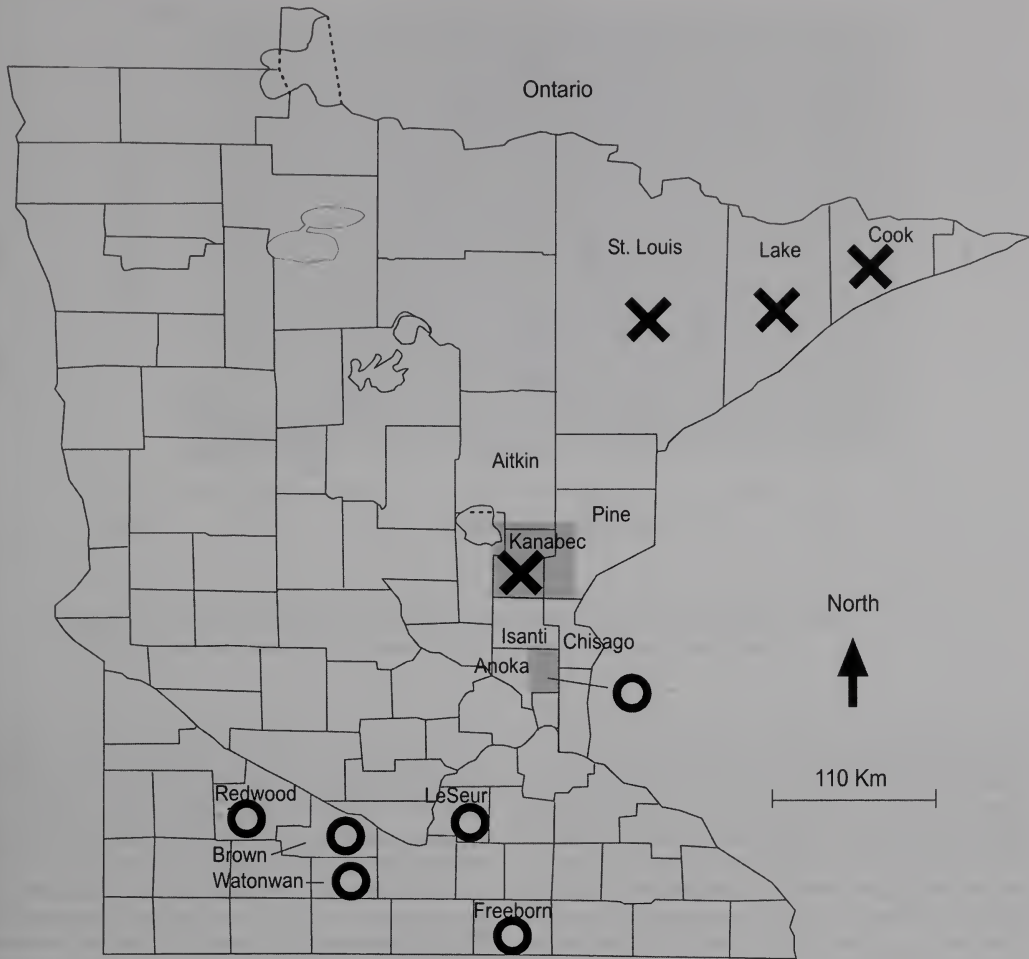


FIGURE 1. Areas where temporal prevalence and distribution of giant kidney worm in Mink were studied (shaded). Counties where worms were known to occur (X) or where not found (O) by this study or by Mech and Tracy (2000).

TABLE 1. Prevalence of giant kidney worm (*Diocotphyne renale*) in eastern Minnesota Mink and capture success.¹

Year	Kanabec and Pine counties				Anoka County ²		
	Mink Caught	Trap Nights	Capture Success (%)	Worm prevalence (%)	Mink Caught	Trap Nights	Capture Success (%)
1998	18	1116	1.61	35			
1999	10	740	1.35	20			
2000	6	310	1.94	50	11	347	3.17
2001	24	960	2.50	92	11	319	3.45
2002	11	363	3.03	82			
2004	14	574	2.44	43	13	624	2.08
2005	16	944	1.69	6	4	348	1.15
2006	6	618	0.97	0	7	546	1.28
2007	5	570	0.88	20	8	512	1.56
Total	110	6195	1.78 ³	35	54	2696	2.00 ³

¹ Considered an index of Mink density
² No worms found in Anoka County Mink and no trapping in Anoka County in 1998, 1999, 2002, or 2003.
³ Average annual success not significant.

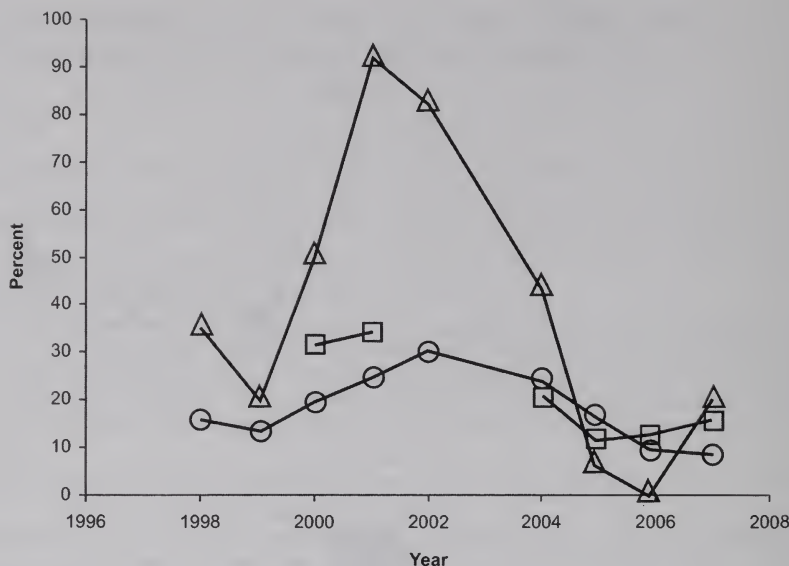


FIGURE 2. Prevalence of giant kidney worms in Mink of east-central Minnesota (triangles), Mink-trapping success rate in worm area (circles) and in worm-free area (squares).

is so. Mink inhabit all types of waterways and feed on a variety of fish, frogs, birds, and mammals, so it is difficult to compare Mink habitat suitability among various areas. The intermediate host of *D. renale* is the water worm (*Lumbriculus variegatus*), and various fish and frogs are paratenic hosts. Because fish and frogs are widespread throughout eastern Minnesota, this strongly implicates the distribution of *Lumbriculus variegatus* as the prime factor causing the difference in the *D. renale* distribution or prevalence. *Lumbriculus variegatus* depends on passive means such as stream flow or perhaps incidental carry by animals in Mink, to increase its distribution (Timm 1980). Therefore, it is understandable how it may live in one watershed but not in another that may be close but across a divide. Thus future research into this subject should include an assessment of *Lumbriculus variegatus* distribution.

My findings that *D. renale* increased and then decreased over a five-year period, peaking at the highest prevalence ever reported in Mink, suggest that prevalence may show cyclicity. The correlation between *D. renale* prevalence and trapping success may indicate that prevalence fluctuates with Mink density. This interpretation assumes that non-infested Mink are just as trappable as infected Mink, an assumption justified by the similarity in trapping success between both study areas, one with *D. renale* and the other without. I had > 20 years' experience trapping Mink with the same methods before the study began, so differences in annual trapping success probably reflect actual differences in Mink density.

The effect of *D. renale* on Mink density is difficult to gauge. The correlation between trapping success in both study areas might suggest that in general *D. renale* has little population effect. However, the fact that the lowest success rates (2006 and 2007) in the *D. renale* area were considerably lower than those in the worm-free area offer some evidence that after Mink reach high densities in the *D. renale* area, and thus high worm prevalence, they might drop to lower density than in the worm-free area. Further research might elucidate this question.

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I thank trappers Gerald Schmidt and Russ Cumberland for providing Mink carcasses from LeSeur, Freeborn, Redwood, Brown, and Watonwan counties; Shawn Tracy for assisting with examining the carcasses; and M. E. Nelson and J. Erb and an anonymous reviewer for critiquing the manuscript.

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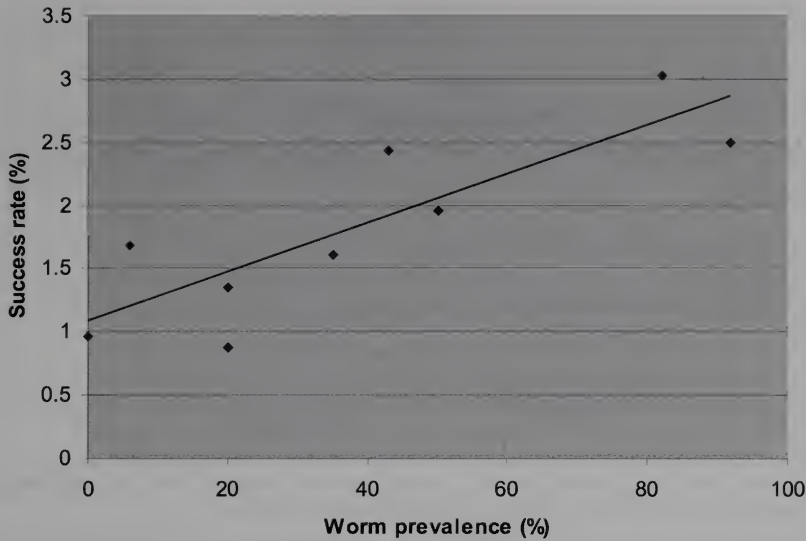


FIGURE 3. Relationship between Mink-trapping success and kidney worm prevalence in Mink; $r^2 = 0.72$; $P < 0.01$; $y = 0.0193x + 1.0782$.

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Notes

Canada Lynx, *Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in New Brunswick and Nova Scotia

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MacKinnon, Colin M. and Andrew C. Kennedy 2008. Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia. Canadian Field Naturalist 122(2): 166-168.

An observation of tracks made by Canada Lynx on the Chignecto Isthmus supports assumed use of this area between New Brunswick and Nova Scotia as a potential wildlife corridor. Use of the isthmus by lynx may facilitate gene flow between otherwise geographically separate populations in Nova Scotia and New Brunswick.

Key Words: Canada Lynx, *Lynx canadensis*, Chignecto Isthmus, wildlife corridor, gene flow, New Brunswick, Nova Scotia, Missaguash Marsh.

The eastern Maritime Provinces of New Brunswick and Nova Scotia are connected by a narrow strip of land (24 km wide) known as the Chignecto Isthmus (Trueman 1896; Ganong 1903). The isthmus is bordered to the west by Cumberland Basin at the head of the Bay of Fundy and to the east by Baie Verte which opens into the Northumberland Strait. The area between these two bodies of water is predominantly composed of dykelands (saltmarshes converted to agricultural lands), freshwater lakes and bogs (the Missaguash Marsh), uplands comprised of mixed coniferous and deciduous woods, and scattered open farmland and dwellings. The actual boundary between the two provinces lies across this isthmus, following the Missaguash River 18.5 km to its head then overland to the Tidnish River (Figure 1). The Chignecto Isthmus is of particular interest as it is the only land bridge connecting Nova Scotia with continental North America and, in the 20th century, at least three large mammals have entered the province via this route (Scott and Hebda 2004).

On the New Brunswick side of the Missaguash River a major highway (Route No. 16) divides the isthmus (a distance of 18.5 km) and connects the villages of Aulac and Baie Verte. Farms and associated large open fields, as well as a number of dwellings, dominate the landscape on both sides of Route 16 except for a narrow 2.5 km strip of densely forested land at the head of the Missaguash Marsh (elevation 20 m), where woodlands border both sides of the highway right-of-way. This highway is also one of the main transportation corridors connecting the Trans Canada Highway (Route No. 1) at Aulac with the Confedera-

tion Bridge and Prince Edward Island. With the exception of the above mentioned forested area, this busy road, combined with the adjacent residential properties and the large expanses of open fields, is likely a barrier to movement of some species of wildlife across the isthmus.

On 12 February 2007, 11:30 am, we recorded tracks of a Canada Lynx, *Lynx canadensis*, crossing a densely wooded section of Route 16 (45°59' N, 64°09' W) at the head of the Missaguash Marsh, 16.3 km east of Aulac, New Brunswick (elevation 17 m). Based on these tracks, the lynx had been moving through dense mixed woods in an area immediately adjacent to the north side of the road. The animal then crossed the road perpendicular to the highway where it immediately headed in a southerly direction, into dense woods, towards Nova Scotia. The tracks were believed to be less than 24 hours old and probably made during the night of 11/12 February 2007. The imprints were distinct with a clear foot impression measuring 7.5 × 7.5 cm. A walking stride, the distance between footprints of the same foot, ranged from 61 to 71 cm. The tracks were not followed into the woods due to insufficient time. Snow depth was about 25 cm with light accumulation made the night before. The last significant snowfall (9.8 cm) was recorded on 3 February, nine days previous to our survey.

The significance of this observation is twofold. First, this evidence of lynx activity emphasizes the importance of the Chignecto Isthmus, especially the remaining densely wooded area at the headwaters of the Missaguash River, as a wildlife corridor between the two provinces. Secondly, this sighting has implications



FIGURE 1. Place names and salient features on the Chignecto Isthmus.

regarding lynx management in Nova Scotia and supports the possibility of gene flow between that province and the nearest known breeding population in north-western New Brunswick.

A wildlife corridor is a protected route that allows wildlife to move safely between areas of suitable habitat (Wilson and Willis 1975). The Chignecto Isthmus, being the only land connection between Nova Scotia and New Brunswick, has long been recognized by biologists, hunters and naturalists as serving a connectivity function for wildlife between the two provinces although no studies have been done to support this assumption. Large, widely ranging carnivores such as American Black Bear, *Ursus americanus*, and lynx are often used as a measure of the value of a possible wildlife corridor. This suggests that, if the needs of the more shy and secretive large mammals are met, so would be those of the smaller but equally important species (Parks Canada 2003*). Thus, this reporting of a single lynx track may have broad significance.

Canada Lynx was listed as endangered in Nova Scotia in 2002. In New Brunswick it was listed as endangered in 1976 and when the New Brunswick Endangered Species Act was revised in 1996, the lynx was listed as regionally endangered; i.e., in danger of dis-

appearing in New Brunswick but remaining healthy elsewhere (Libby 2002*). For the past 40 or 50 years the breeding population of lynx in Nova Scotia has been restricted to the Highlands of Victoria and Inverness Counties, Cape Breton (Banfield 1974; Parker 1981; Parker et al. 1983), although, on occasion, occurrences have been reported on mainland Nova Scotia (Parker 2001*). In New Brunswick, lynx are restricted to the extreme northwest with only occasional sightings and trapping recoveries in the southeast (Cumberland et al. 1998; Parker 2001* and Libby 2002*). Any such overland movement between New Brunswick and Nova Scotia would have to be through the Chignecto Isthmus and, prior to our observation, we know of no previously documented lynx occurrence in this region. Donald Colpitts, a retired Forest Ranger with the New Brunswick Department of Natural Resources and Wildlife Technician for the Canadian Wildlife Service, has trapped furbearers on the isthmus and surrounding marshes for over fifty years. He also operated a trap-line in British Columbia and can readily differentiate tracks of lynx from those of similar sized mammals such as Bobcat, *Lynx rufus*, Red Fox, *Vulpes vulpes*, or Eastern Coyote, *Canis latrans*. He has never observed tracks of Canada Lynx on the Chignecto

Isthmus (D. W. Colpitts, personal communication). Although the frequency of lynx crossing the Chignecto Isthmus are probably very low, there have been recent reports of tracks and sightings in southeastern New Brunswick (C. Libby, personal communication) and one animal was accidentally snared in November 1987 near Hopewell Cape in Albert County (McAlpine and Heward 1993), only approximately 36 km west of our observations.

Long distance travel by lynx may be quite common. Poole (1997) reported that lynx in the Northwest Territories travelled an average of 163 km during the first winter following a Snowshoe Hare (*Lepus americanus*) decline and Schwartz et al. (2002) demonstrated high gene flow between widely separate lynx populations (greater than 3100 km) in northwestern North America. Our observations confirm the potential for lynx to cross the isthmus, between the two provinces, and would allow for gene flow between the breeding populations on Cape Breton Island and northwestern New Brunswick. As supported by our observation, the densely forested land, at the headwaters of the Missaguash Marsh on the Chignecto Isthmus, still holds potential as a wildlife corridor for inter-provincial movement of large secretive carnivores such as lynx. The maintenance of this corridor is important so that lynx on Cape Breton Island do not become genetically isolated but remain part of the greater North American population. Conservation of this area and its forested habitat may facilitate the continued use of the isthmus as a wildlife corridor for many species, including lynx, and thus limit the effect of land use changes that could hinder such movement.

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First Occurrence of the Grey Fox, *Urocyon cinereoargenteus*, in New Brunswick: a Climate-change Mediated Range Expansion?

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The first occurrence in New Brunswick of the Grey Fox (*Urocyon cinereoargenteus*), a threatened species in Canada, is documented based on a 4.3 kg subadult male trapped in the southwestern corner of the province. This is an approximate range extension of 135 km from the most northerly Maine occurrence and may reflect a larger North American range expansion underway since 1930-40, perhaps in response to warming climate.

Key Words: Climate change, distribution, Grey Fox, New Brunswick, threatened species, *Urocyon cinereoargenteus*.

In Canada, the Grey Fox (*Urocyon cinereoargenteus*) has been assessed as a threatened species (COSEWIC 2002*). It is estimated that fewer than 250 mature individuals make up the entire Canadian population, although it seems likely that only on Pelee Island, Ontario, does a Canadian breeding population now exist (Judge and Haviernick 2002*). Records from the Rainy River District of Ontario west into southern Manitoba and mainland southeastern Ontario are thought to be dispersing individuals from south of the Canadian border (Judge and Haviernick 2002*). A single Grey Fox trapped near Lake Athabasca, Alberta, in 1950 is considered extra-limital (Moore 1952; Fritzell and Haroldson 1982) or perhaps even an escaped captive (Fritzell 1987). Judge and Haviernick (2002*) report that there have been no confirmed records of the Grey Fox in Quebec in over 100 years and that all Canadian reports of the Grey Fox from the past 20 years have been from Ontario. Here we document the first specimen of the Grey Fox in New Brunswick, placing this occurrence in the context of a range expansion underway since 1930-1940 that is perhaps the result of a warming climate.

On 29 October 2007 JDM trapped a Grey Fox on the west side of the Digdeguash River 0.75 km NNW of Rollingdam, Charlotte County, New Brunswick (45.320°N, 67.075°W). The location is approximately 34 km east of the Maine-New Brunswick border and about 135 km northeast of the most northerly Maine Grey Fox sighting reports from just north and northeast of Bangor (W. Jakubas, personal communication to DFM). The fox was taken in a 330 body-gripping conibear trap set for Beaver (*Castor canadensis*) on a trail about 1 m from the water's edge 0.35 km west of Rollingdam Road. The site is in mixed forest dominated by Balsam Fir (*Abies balsamea*), poplar (*Populus* sp.) and Grey Birch (*Betula populifolia*). There are many commercial blueberry fields in the area, and woodlots nearby have been selectively cut.

Measurements of the specimen are as follows: total length 1001 mm, tail vertebrae 304 mm, hind foot 125.4 mm, ear 61.2 mm, weight 4.3 kg, testes both about 13.5 mm × 3.0 mm. The animal was judged to be subadult on the basis of degree of closure of skull sutures, tooth wear, and mean eye lens weight (81.15 mg), after Wood (1958) and Lord (1961). The full stomach contained the remains of a Ruffed Grouse (*Bonasa umbellus*). Seven adult cestodes of *Taenia pisiformis* were removed from the upper small intestine. The skin, skeleton, and eye lenses have been deposited in the New Brunswick Museum mammal collection (NBM 6212) and vouchers of *T. pisiformis* are now in the NBM invertebrate collection (NBM 7172).

Fitzell (1987) has noted that knowledge of dispersal movements is important in understanding Grey Fox population dynamics. In Alabama dispersal movements of juvenile Grey Foxes start in October, with this behaviour most pronounced in males. The New Brunswick record reported here clearly fits the pattern of a post-natal dispersal movement but suggests that these movements can on occasion be greater than the maximum of 84 km reported by Sheldon (1953). Buechner (1944) reports a mean infection rate of 9.6 *T. pisiformis* per Grey Fox. The presence of adult *T. pisiformis* strongly suggests feeding on a lagomorph (Jones and Bybus 2001); Elleker (1984*) recorded an infection rate of 85% for larval *T. pisiformis* in Varying Hares (*Lepus americanus*) in southern New Brunswick. Adults of this cestode are generally frequent in canids (Miller and Harkema 1968).

Archaeological evidence demonstrates that before European settlement of eastern North America the Grey Fox was a common mammal in southern Ontario and, in the east ranged north to at least Cumberland County, in southwestern Maine (Wintemberg 1921; Palmer 1956). For reasons that remain unclear, about 350 years ago the species disappeared from the northern portion of its range in eastern Canada, northern

New England, and some of the Great Lakes states. However, since 1930-1940 the Grey Fox has re-occupied areas north and east of central New York and Connecticut and perhaps even expanded what was its historic range in New England, the Midwest, Ontario, and Manitoba (Fritzell and Haroldson 1982; Judge and Haviernick 2002*). It has been suggested that the current range expansion may be the result of a general warming trend since 1850 (Waters 1964); in Wisconsin and Minnesota this climate-mediated range expansion may be as recent as the 1990s (Judge and Haviernick 2002*). Palmer (1956) implicates the spread of cottontail rabbits (*Sylvilagus* sp.), a prime prey species for the Grey Fox (Fritzell and Haroldson 1982), and the replacement of woodland with agricultural habitats, in the species range expansion in the northeast. However, it should be noted that the most northerly sighting reports of Grey Fox in Maine are now beyond the range for *Sylvilagus transitionalis* in that state and that the range of the New England Cottontail in Maine is now contracting, apparently in response to forest maturation (Boone and Krohn 1998*). Conversely, Boone and Krohn (1998*) report that Grey Fox numbers in Maine appear to be increasing in response to this factor. Fritzell (1987) also emphasizes that changes in land use, including agricultural activity in the northeast, have created conditions that favour the Grey Fox. Although several studies have shown that the Grey Fox has a preference for old fields (Fritzell and Haroldson 1982), the species is closely associated with deciduous forest and especially forest edge habitats (Fritzell 1987).

Recent trapping records for Grey Fox in Maine suggest that the species remains concentrated in the southern counties, including and north of Cumberland. This latter county is where Palmer (1956) documented the first recent (1955) Maine occurrence. However, Maine fur harvest records also suggest a now well-established Grey Fox population with an average of 134 pelts/year (range 67-196) taken in the state from 2001-2002 through 2006-2007. Clearly, Grey Fox numbers have increased dramatically in Maine during the past 50 years (Boone and Krohn 1998*). Occurrence of the Grey Fox in New Brunswick appears to be part of this northward expansion in population and range that has been underway in Maine for the past half-century. It also reflects a more general North American re-occupation and expansion in range for the species since 1930-1940. Although Judge and Haviernick (2002) report that there have been no confirmed records of the Grey Fox in Quebec in over 100 years, this may be incorrect. Although the Grey Fox is certainly still very rare in southern Quebec, current information indicates the Grey Fox is present in Quebec in the region near Lacolle (45.09°N, 43.37°W), about 8 km north of the Vermont border. Although trapping this species in Quebec is prohibited, about one Grey Fox has been taken accidentally in the Lacolle region each year over

the past five years (D. Blannville, personal communication to DFM).

Judge and Haviernick (2002*) suggest that a warming climate should make Canada more attractive to the Grey Fox in the coming decades. Coupled with this milder weather is a predicted shift in northeastern North America towards a forest dominant by deciduous tree species and a loss of spruce-fir habitat (Iverson and Prasad 2001). Both of these factors should favour the Grey Fox in the region in the future.

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Allonursing and Cooperative Birthing Behavior in Yellowstone Bison, *Bison bison*

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We document allonursing and cooperative birthing behavior in wild Bison near Yellowstone National Park in the western United States. During spring 2007, two female Bison nursed each other's newborn calves and mutually cleaned both calves and consumed expelled birth material. Intensive cooperative birthing behavior has never been documented in wild Bison before. This observation of allonursing might be explained by kin selection and reciprocal altruism.

Key Words: Bison, *Bison bison*, alloparental care, allonursing, Yellowstone National Park, Montana.

Alloparental care, the investment of resources toward the survival of another's offspring (Hamilton 1964) is expected to negatively affect future reproductive success and the survival of current offspring through physiological stress (Heinsohn and Legge 1999; Roulin 2001). However, this apparently altruistic behavior has been documented in 120 mammalian and 150 avian species (Riedman 1982). In mammals, the nursing of non-genetic offspring, allonursing, is a form of alloparental care that has been observed in 68 mammalian species (Packer et al. 1992; Roulin 2001). The costs and benefits of this energetically expensive behavior are unclear, especially in mammals living in temperate environments where food resources sustaining lactation are limited seasonally.

We observed a unique birthing event and allonursing in Bison (*Bison bison*) on 27 April 2007 along the shoreline of Hebgen Lake (44°45'N 111°13'W) near West Yellowstone, Montana. Two female Bison, aged 4-7 years, gave birth within an hour of each other at the same location and shared in the care of each other's calves. Following each birth, both females simultaneously licked the newborn calf and consumed the expelled birth material. Both females also consumed the retained placental tissue protruding from the other birthing female. Each calf was seen nursing from both



FIGURE 1. Two newborn Bison calves simultaneously nursing from one female during a cooperative birthing event near Yellowstone National Park, Montana, on 27 April 2007. National Parks Service. Photo by Carrie Byron.

females shortly after parturition (Figure 1). We monitored the females and newborns for 5.5 hours, during which the females demonstrated aggressive behavior toward other Bison approaching the birth sites. This is the first documented observation exhibiting intensive cooperative birthing behavior in wild Bison.

The benefits of allonursing in Bison should outweigh the costs; otherwise a female should not sacrifice her resources at the expense of her own calf's survival. This behavior has been explained through kin selection (Hamilton 1964), reciprocity or sharing the burden with another female (Roulin 2001; Clutton-Brock 2002), and limited parenting experience (Riedman 1982). Female Bison imprint on the first calf they contact after giving birth and, while this is usually their calf, it is possible in a herd to mistakenly adopt another female's calf through lack of parenting experience (Lott 1972). Since the females in the observation were estimated to be of prime reproductive age, it is unlikely that this was their first pregnancy and does not lend support for lack of experience as an explanation. We do not know the level of genetic relatedness of the birthing females and therefore can not endorse a strong kin selection explanation for the observed behavior.

Both kin selection and reciprocity may explain our observation of allonursing and cooperative birthing behavior. The sharing of birthing responsibilities between two females benefits both of them, even if they are genetically unrelated. Shared nursing responsibilities could be beneficial to both females if the mammary glands of one female become depleted temporarily. The behavior also provides temporary relief from maternal duties, or each calf receives a greater variety of immune compounds by nursing from multiple females (Roulin 2001). Additionally, Bison calves are targeted by Grizzly Bears (*Ursus arctos*) and Wolves (*Canis lupus*) in Yellowstone National Park. Reciprocal behavior extending beyond allonursing to protection from predators may increase the survival probability of newborn Bison. Though Bison are highly social and display cooperative behavior with offspring of other herd members, previously reported cases of alloparental care in Bison are limited. McHugh (1958) did report four instances where Yellowstone Bison

calves, ranging from 30 minutes to 20 days old, began to nurse on a cow other than their mother but no details about the cow's reaction is given and it is unclear if the calves were immediately rejected or allowed to nurse. To our knowledge, this is the first documented case of allonursing and extensive cooperative birthing behavior in wild Bison.

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Weight Changes in Wild Wolves, *Canis lupus*, from Ages 2 to 24 Months

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Mech, L. David 2008. Weight changes in wild Wolves (*Canis lupus*) from ages 2 to 24 months. *Canadian Field Naturalist* 122(2): 173-175.

Weights of 118 female and 141 male Minnesota Wolves (*Canis lupus*) aged 2-24 months increased almost linearly from about 8 kg for females and 10 kg for males at 3 months to 30 kg for females and 32 kg for males at 10-12 months and then tended to increase much more slowly in an overall curvilinear trend. Considerable variation was apparent for both sexes during their first year.

Key Words: Wolves, *Canis lupus*, weights, growth, development, Minnesota.

Weight changes in free-ranging Wolves (*Canis lupus*) from 3 to 7 months of age have been documented (Van Ballenberghe and Mech 1975), as well as annual changes from 1 to 12 years (Mech 2006). However, weight changes between 7 months and 24 months have not yet been described for wild or captive Wolves. Thus information about the growth and development of wild Wolves remains incomplete. Herein I present information that helps fill that gap.

The study area encompassed some 2060 km² immediately east of Ely in the east-central Superior National Forest (48°N, 92°W) of northeastern Minnesota. Winter temperatures below -35°C are not unusual, and snow depths (usually from about mid-November through mid-April) generally ranged from 50 to 75 cm. Temperatures in summer rarely exceeded 35°C. Conifers predominate in the forest overstory interspersed with large stands of Paper Birch (*Betula papyrifera*) and Trembling Aspen (*Populus tremuloides*). Detailed descriptions of the forest vegetation were presented by Ohmann and Ream (1969).

Wolves in the study area feed primarily on White-tailed Deer (*Odocoileus virginianus*), Moose (*Alces alces*), and Beavers (*Castor canadensis*; Frenzel 1974). The Wolves have been legally protected since 1974, although some have been killed accidentally or illegally by humans (Mech 1977). The Wolf population in the study area has remained relatively stable since about 1975, after dropping following a major deer decline (Mech 2000:23). The study population has long been saturated and in the late 1970s, canine parvovirus infected the population, resulting in a strong decrease in young pup survival ever since (Mech et al. 2008).

The taxonomic identity of the Wolves in this study is uncertain. Nowak (1995) considered them *Canis lupus nubilus* based on skull morphology. However, the population includes animals with the same mitochondrial DNA haplotypes as some Wolves in Alaska and western Canada, as well as animals with Coyote (*Canis latrans*)-like haplotypes also found in eastern Ontario (Lehman et al. 1991). Nevertheless no morphological differences between Wolves of these two

mitochondrial DNA haplotypes have been recognized, and both types inhabit the same packs (Lehman et al. 1992). Wilson et al. (2000) suggested that Minnesota Wolves may be assignable to a newly postulated species, *Canis lycaon*. A less powerful genetic test was consistent with the population being *Canis lupus* or hybrids between *Canis lycaon* and *Canis lupus* (Mech and Federoff 2002).

Most of the Wolves I studied were live-trapped in modified, steel foot traps (Mech 1974) from about 16 Wolf packs throughout the study area from June through December 1970 through 2006. The Wolves were anesthetized and weighed on a spring scale, (Chatillon 160, Largo, Florida, until 1999; and Salter ABS, Santee, California, since then). Pups were distinguished by their milk teeth or newly erupted adult canines (Van Ballenberghe and Mech 1975). Two male and two female pups were then outfitted with capture collars (Mech and Gese 1992), anesthetized remotely, and weighed 6-11 times more through ages 23 months for females and 19 months for males. Contrary to animals captured in live-traps, those captured by capture collars sometimes have food in their stomachs. I estimated the amounts by observing the degree to which the stomachs were distended and subtracted those estimates from the total weights.

Weights were obtained from 152 captures of 118 females and from 176 captures of 141 males. Weights of both sexes increased almost linearly from about 8 kg for females and 10 kg for males at 3 months to 30 kg for females and 32 kg for males at 10-12 months and then tended to level off and increase more slowly (Figure 1). Considerable variation was apparent for both sexes during their first year. This variation is no doubt due to variation in amount of food available as well as to competition within litters for the available food. In addition, some pups with low weight might not have survived long enough to contribute data as older pups.

These results agree with Kuyt (1972) for captive Wolves 1-3 months old and those of Pulliainen (1965, cited in Mech 1970: 124) for single captive Wolves

Figure 1A.

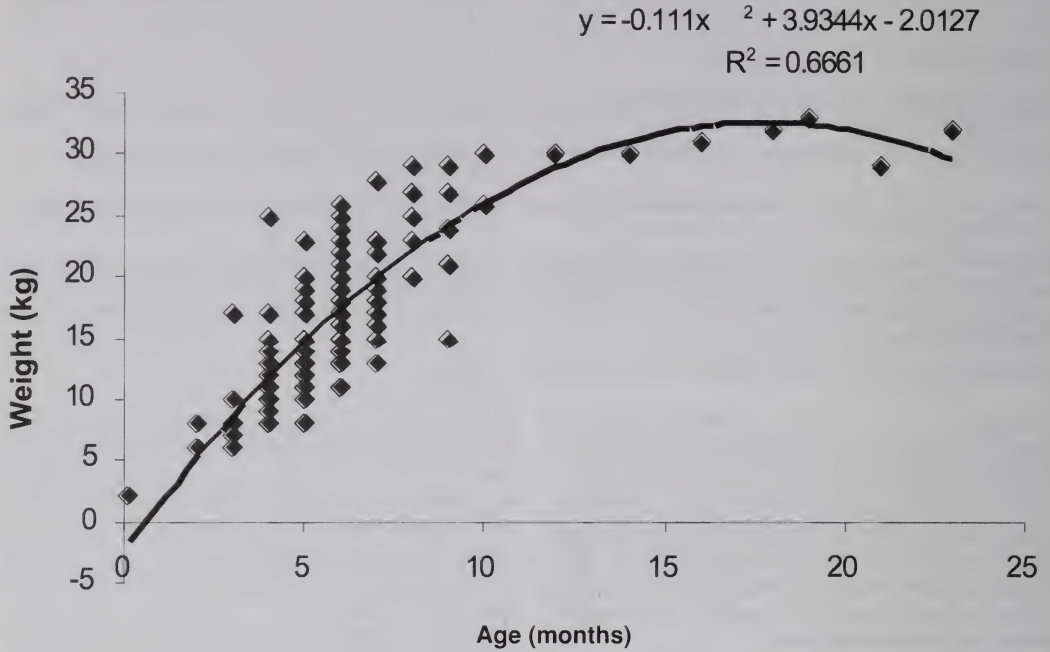


Figure 1B.

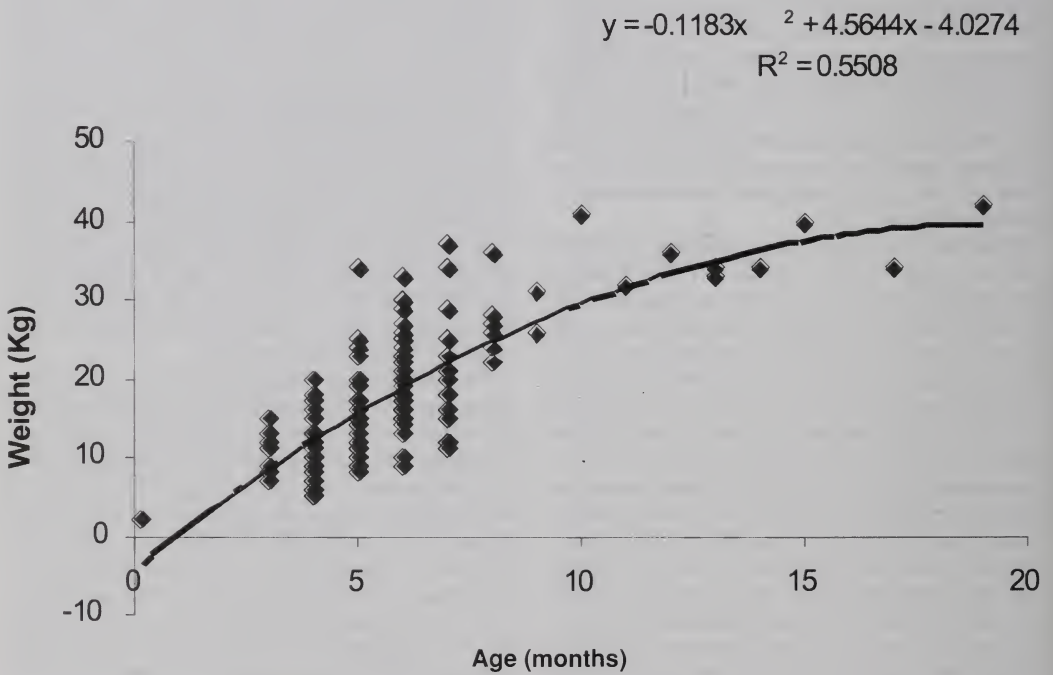


FIGURE 1. Weight changes in Wolves from the Superior National Forest in northeastern Minnesota, 1970-2006. A. females 2-23 months old (1970-2004). B. males 3-19 months-old, (1970-2006). (Assumed 0.5 kg birth weight to complete trend line [Rutter and Pimlott 1968].)

from 3 to 7 months. However growth of Pulliainen's (1965) Finnish captives began leveling off at 7 months (female) and 11.5 months (male) rather than at about 12 months for both sexes of Minnesota wild Wolves. It is not clear whether the difference in age of growth leveling off is due to different races of Wolves or better nutrition of captive Wolves.

This study helps complete general information about the weight changes of wild Wolves from about 3 months of age to 12 years of age (Mech 2006). Overall, the pattern of weight gain in wolves within the first two years of age followed a curvilinear relationship. However, more data are still needed for both male and female Wolves 5-12 years old.

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Evidence of Raccoon, *Procyon lotor*, Range Extension in Northern Alberta

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Latham, A. David M. 2008. Evidence of Raccoon, *Procyon lotor*, range extension in northern Alberta. Canadian Field-Naturalist 122(2): 176-178.

The northern limit of Raccoon (*Procyon lotor*) distribution in northeastern Alberta and northwestern Saskatchewan remains unclear. I report an observation of a Raccoon that supports claims that this species has expanded its range well into the boreal forest of northeastern Alberta. Agriculture, industrial activity, and global warming may be important factors in facilitating Raccoon range expansion in the boreal regions of Alberta and Saskatchewan.

Key Words: Raccoon, *Procyon lotor*, distribution, range extension, agriculture, northern Alberta.

The distribution of Raccoons (*Procyon lotor*) across much of their northerly extent remains unclear (Larivière 2004). In pre-Columbian times Raccoons were most abundant in the southwestern USA (Zeveloff 2002). It is believed that their northward range expansion to the Canada-United States border occurred in the late 1800s and early 1900s, although they likely remained uncommon in Canada (Zeveloff 2002; Larivière 2004). Currently, Raccoons are widespread throughout the prairies of Alberta and Saskatchewan (Smith 1993; Gehrt 2003). It is generally accepted that their expansion into the Canadian prairies occurred slowly throughout the early- to mid-1900s, gaining momentum in the latter part of the century (e.g., Houston and Houston 1973). However, uncertainty arises around how far north Raccoons have managed to penetrate into the northern agricultural zone and boreal forest in northeastern Alberta and northwestern Saskatchewan (Smith 1993).

Larivière (2004) suggests that the capture of a large male Raccoon in 1930 near a logging camp in the Birch Mountains, Lake Claire area (approximately latitude 58°00'N; longitude 112°20'W; Figure 1), northeastern Alberta, was probably an escaped pet or clandestine rider on logging trucks traveling to and from areas farther south (reported in Soper 1942). Raccoons had not been documented from this region of northeastern Alberta previously (Soper 1942). Larivière (2004) recommends that northeastern Alberta and northwestern Saskatchewan should not be included in the normal distribution of Raccoons. I report an observation in northeastern Alberta which indicates that this may not be correct, and suggest that although Raccoons are uncommon in the north they be increasing (Smith 1993).

In February and March 2004, I conducted a carnivore inventory near the town of Wabasca (latitude 55°57'N; longitude 113°49'W) in northeastern Alberta. The study area consisted of about 10 000 km² of boreal mixed-wood and peatland vegetation. With the exception of a small ranch on the west-central boundary of the study area, the nearest agriculture was approxi-

mately 50 km south of the southern boundary. I used hair removal sites ($n = 116$) to assess the distribution of Wolves (*Canis lupus*) and Coyotes (*Canis latrans*) within the study area. Other species were also sampled incidentally at some of the hair snares. Hair removal sites consisted of 2 strands of barbed wire (approximately 30 and 60 cm above the ground) wrapped around four trees to form a 2 × 2 m grid. Sites were baited with a rotten Beaver (*Castor canadensis*) carcass and checked for hair on three occasions post baiting. Hair samples were collected, dried and placed in paper coin envelopes for subsequent DNA analysis. Species testing consisted of a sequence-based analysis of the 16S rRNA, mtDNA gene (see Johnson and O'Brien 1997 for further details). Results were compared with a comprehensive reference data set.

On 22 February 2004, I checked a site coded "515" (55°37'N; 113°02'W) for the first time post-baiting (10 February 2004) (Figure 1). Although snow conditions were poor due to an icy crust, I noted a set of tracks that were very unusual. In hindsight it seems most likely that these tracks were Raccoon, although I did not consider this option at the time as the northernmost extent of their range was supposed to be several hundred kilometres to the south (Smith 1993; Gehrt 2003; Larivière 2004). Unidentified hair was collected from site 515 on two occasions (22 February and 4 March) and sent for subsequent DNA analysis. DNA results positively indicated that both hair samples came from one or more Raccoons (we did not identify hair samples to the individual).

Site 515 was 592 m above sea level, and was characterized by a mosaic of small lakes, streams, boreal mixed-wood (Trembling Aspen, *Populus tremuloides*, and White Spruce, *Picea glauca*), and peatland (Black Spruce, *Picea mariana*, and Tamarack, *Larix laricina*) vegetation. The closest paved road was approximately 23 km to the west (although industrial roads associated with the oil and gas industry were common). The closest agriculture was more than 60 km south of this site (Figure. 1). Due to the scarcity of merchantable timber

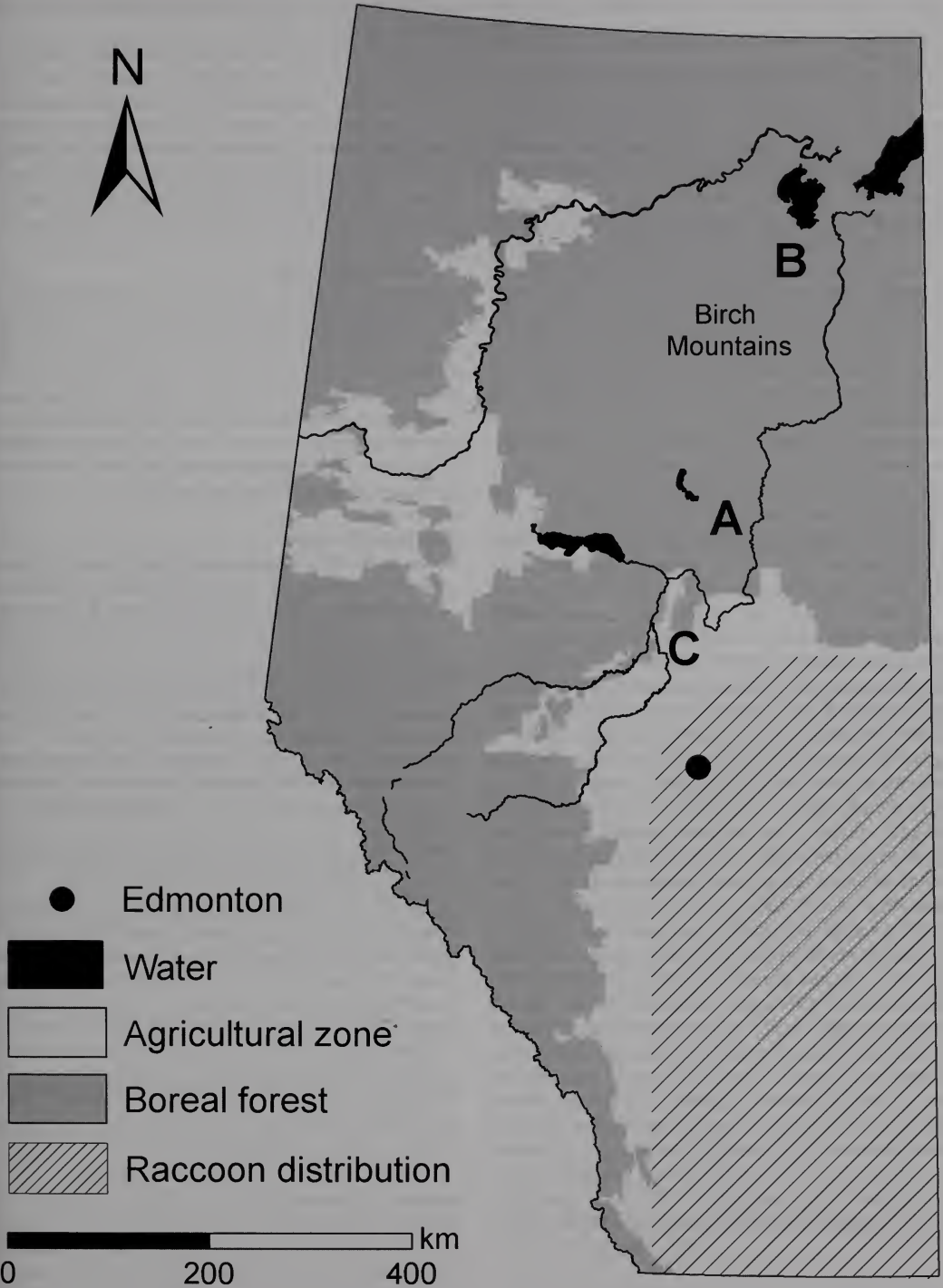


FIGURE 1. A map of Alberta, Canada, showing the extent of the agricultural and boreal forest zones, the current distribution of Raccoons, *Procyon lotor* (adapted from Smith 1993), and the locations within the boreal forest of northeastern Alberta where Raccoon presence has been identified. A represents site 515 where Raccoon presence was identified via DNA analysis of hair samples (the Athabasca River is located to the east of site A); B is the approximate capture location (near Lake Claire) of a male Raccoon in 1930 (reported in Soper 1942); and C is the location of a pilot study near the Pembina River that identified Raccoon tracks at one sample site.

in this peatland-dominated area logging is rare; the closest logging was approximately 10 to 15 km to the west of this site.

This observation provides support to earlier assertions that Raccoons are found in the boreal forest of northeastern Alberta (e.g., Hall and Kelson 1959). It is unlikely that this observation represents a case of an escaped pet or that the individual was perhaps transported to the area by a truck hauling logs or hay as suggested for an earlier observation (Larivière 2004). Site 515 was situated in a mix of large deciduous and coniferous trees, near streams and small lakes, and consequently appears to be suitable habitat for Raccoons (Wooding 1982; Smith 1993; Gehrt 2003). However, the greater habitat matrix surrounding site 515 was composed primarily of Black Spruce bogs and Black Spruce-Tamarack fens, a most unusual habitat for Raccoons.

I agree with Larivière (2004) that the most parsimonious explanation for the northern range expansion of the Raccoon in central Canada is the increase in food abundance associated with agriculture and perhaps human footprint more generally. Similarly, global warming has likely played a role (Voigt 1984; Larivière 2004); less severe winters could allow Raccoons to expand (at least temporarily) into more extreme environments. Some of the farmers on the boreal-agricultural fringe in northeastern Alberta claim that they frequently see Raccoons, particularly near rivers and streams. A pilot study conducted in 2003 along the Pembina River (near Fawcett; 54°32'N; 114°08'W; Figure 1) supports the claim of Raccoon presence near rivers in the boreal-agricultural fringe (A. D. M. Latham, unpublished data). This study used baited sooted-track plates to inventory small- to medium-sized carnivores in the region; Raccoon tracks were identified on a track plate at one of the sites that was assessed (A. D. M. Latham, unpublished data).

It is possible that riparian features serve as vectors to exploratory movements and range expansion (Smith 1993). Large rivers, such as the Athabasca River, and a finer network of smaller rivers and streams course throughout the boreal forest near Wabasca, and it is possible that the Raccoon observation noted here was a result of a dispersal event along such a riparian feature. As the current observation occurred toward the end of the Raccoon mating season (Voigt 1984), it could represent a wide-ranging movement by a male searching for mates. Interestingly, the individual reported from the Birch Mountains in 1930 was a male (Soper 1942), and consequently could have represented a

similar dispersal in search of mates, possibly along the nearby Athabasca River.

In summary, the current observation of a Raccoon well into boreal forest appears to suggest that Raccoons may have penetrated farther into the boreal forest in northeastern Alberta than previously thought (Larivière 2004). Further research is needed to help elucidate the distribution of Raccoons in northeastern Alberta, and to help shed light on the specific mechanisms responsible for northward range expansion.

Acknowledgments

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Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central Alberta

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Kuzyk, Gerald W. and Robert J. Hudson. 2008. Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central Alberta. *Canadian Field-Naturalist* 122(2): 179-181.

Using hunter-harvested deer in the fall of 2003, we compared ruminal papillae density, length, width, surface enlargement factor (SEF) and reticular cell diameter between sympatric Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*O. virginianus*), and between age-gender classes within each species. There was no difference in papillae morphology or reticular cell diameter between Mule Deer and White-tailed does or bucks or between any age-gender comparisons within species. Female Mule Deer fawns had larger reticular cell diameters than White-tailed Deer fawns, and male Mule Deer fawns had higher papillae density and larger reticular cell diameters than male White-tailed Deer fawns. Papillae widths of male White-tailed Deer fawns were greater than those of male Mule Deer fawns. Comparisons of papillae morphology between Mule Deer and White-tailed Deer sampled during late fall suggests adults of these species may respond similarly to forage quality, but species differences may be evident in fawns.

Key Words: Alberta, Mule Deer, Papillae, Rumen, White-tailed Deer.

Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*O. virginianus*) occur sympatrically over much of western Canada but despite similarities in habitat use and diet, few studies have documented their foraging ecology on northern ranges (Kramer 1973). Comparing gastrointestinal characteristics of deer is one method to understand their relationship with forage quality and quantity (Hoffman 1989; Ramzinski and Weckerly 2007). The forestomach of deer, like other ruminants, contains a mucosal membrane that is enlarged by papillae. Papillae absorb volatile fatty acids that are products of microbial digestion, and growth of papillae is stimulated by production of these volatile fatty acids (Tamate et al. 1962; Hoffman 1989). The size, density and distribution of papillae can be affected by availability, quality and quantity of forage (Hoffman 1988) and can be used to compare habitats and seasons as well as species, age and gender differences (Zimmerman et al. 2006). Research on rumen papillation of cervids has been conducted on Moose (*Alces alces*) (Hoffman and Nygren 1992), Red Deer (*Cervus elaphus*) (Lentle et al. 1996), Reindeer (*Rangifer tarandus*) (Knott et al. 2005), Mule Deer (Short 1981), White-tailed Deer (Short 1964), and sympatric Mule Deer and White-tailed Deer (Zimmerman et al. 2006).

This study adds to the growing body of knowledge by comparing papillae characteristics of sympatric Mule Deer and White-tailed Deer during the rut on northern ranges when the vegetation has cured (November). We sought differences in these closely related and ecologically similar species that might explain their coexistence. We tested whether papillary characteristics might reveal dietary differences. We pre-

dicted that varied diets between genders during the rut would also be evident.

Methods

This study was conducted at the Western Area Training Centre (Department of National Defense) that encompasses about 610 km² near the city of Wainwright, Alberta, Canada (52°N, 110°W). The landscape is an aspen parkland environment consisting of trembling aspen (*Populus tremuloides*) bluffs interspersed with grasslands (Strong 1992). Since 1966, there has been a closely regulated deer hunt in the centre with a mandatory hunter check station (Moore 2003*). In November and December of 2003, we gathered forestomach samples from hunter-harvested adult and fawn Mule Deer and White-tailed Deer. These deer were aged according to tooth wear patterns (Severinghaus 1949) with fawns being classed as being 6-8 months old.

We randomly cut one 2 cm² subsample from the forestomach (Zimmerman et al. 2006) and one 2 cm² subsample from the reticulum of individual deer and placed the samples in a freezer within 12 hours. A 1 cm² sample was later used to determine papillae density (number/cm²) and 10 papillae were measured to determine maximum length and width. We calculated a surface enlargement factor (SEF) following Hoffman and Nygren (1992) where:

$$[(2 \times \text{papillae surface}) \times \text{papillae number} + \text{base surface/base surface}].$$

Ten reticular cells were measured to obtain diameters. Means were calculated for each metric and used to represent one deer. We used a Mann-Whitney U-test

Deer fawns had longer papillae than White-tailed Deer fawns, but the papillae were not as wide suggesting that increasing absorptive surface area is achieved in different ways in the two species at least at younger ages.

No intraspecies differences in rumen morphology were found between does and bucks during the rut. Mature bucks reduce their food intake during the rut, but food reduction might not have a large influence on papillae morphology. There was a large influx of hunters during our sampling period (approximately 100/week) (Moore 2003), which could disrupt foraging behavior among all age and gender classes. Further studies should try to garner larger sample sizes to examine potential seasonal and behavioral effects on papillary morphology of deer in relation to hunting seasons and the rut.

Acknowledgments

This study was supported by a research grant through the Alberta Conservation Association and logistical support was provided by Lakeland College, Vermilion, Alberta, and Department of National Defence. We appreciate the field assistance of Nathan Carruthers, George Lasich, Ken Lehman and numerous Lakeland College Wildlife students and K. Kuzyk and A. Lockwood for all the meticulous laboratory work. Thanks to the many cooperative hunters as well as Dave Moore and other numerous staff from Alberta Sustainable Resource Development and Department of National Defence.

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Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars a AUD and so on. You will find these are the codes now used by financial institutions and internet currency converters. I will include an updated note for the next few issues as a reminder.

ZOOLOGY

Handbook of the Birds of the World Volume 10

By Josep del Hoyo, Andrew Elliott and David A. Christie (Editors). 2005. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 896 pages. 205.00 Euros. Cloth.

This edition goes from Cuckoo-shrikes, Bulbuls, Leafbirds, Fairy-bluebirds, Ioras, Silky-flycatchers, Waxwings), Hypocolius, Palmchat, Dippers, Wrens, Mockingbirds and Thrashers, Accentors to Thrushes and covers a total of 723 species. Following the *Handbook of Birds of the World's* well-established format there is an introduction to each family covering systematics, morphology, habitat, behaviour, voice, food, breeding, movements, relationship with man, and status and conservation. Each species has its own account and this includes taxonomy, status and distribution, descriptive notes, habitat, food and feeding, breeding, movements, and status and conservation. This material was contributed by 16 expert authors.

The book begins with an essay on the ecology and impact of non-indigenous birds by Daniel Sol, Tim Blackburn, Phillip Cassey, Richard Duncan and Jordi Clavell. This is a well-researched article that I found fascinating to read. While it does not understate the problems I found the text factual and free of unwanted emotion. Introduced species are a serious issue and this text provides a sound perspective.

Handbook of Birds of the World continues to provide a chapter for each family that includes a description of the family and the systematics, morphology, habitat, general habits, voice, food and feeding, breeding, movements, relationship with humans, status and conservation. All of this is provided in clear, logical format with first-rate illustrations to complement the text. The cuckoo-shrike family varies from the predominantly grey cuckoo-shrikes to the bright red minivets. I found this book useful in verifying the differences between the Small Minivet and the Scarlet Minivet. The bulbuls are a widespread family of 138 species confined to the Old World. Some, like the Red-vented Bulbul are common, noisy and abundant. Others are more restricted, like the golden yellow Andaman Bulbul which is confined to two small islands in the Indian Ocean. The leafbirds are a small family bright green, look-alike little birds, often accented by blue or yellow. The wrens

are a very widespread family. Despite most of them being variations on brown, black, and white, many are strikingly different in plumage. Even more varied are their habits and songs. The information available on these shy sprites is often sparse [the Tooth-billed Wren has scarcely two dozen lines of text], while the familiar Northern [Winter] Wren has well over a full page, including 44 described subspecies! This allows us to compare the European Jenny Wren with our Winter Wren [and indeed the east and west coast Canadian birds].

The Mimids [Mockingbirds, catbirds and thrashers] are confined to the Americas although some are restricted to single islands. The book ends with the thrushes, a huge family of 336 species, spread from the far north of Greenland to Tasmania. About half are typical thrushes like the American Robin; another group is the chats like the Eurasian Robin. This family has some of the best-loved birds with their gentle round heads and eyes and confiding nature. One of the most handsome is the Varied Thrush as admirably depicted by the photo on page 521. Similarly the photo of the European Robin landing on a frost-rimed tree is superb. But the most spectacular photo is a group of five thrushes [Blackbird, Redwing, Mistle Thrush, Fieldfare and Song Thrush] in a neat circle feeding on an apple in the snow. The photo I like the best, however, is the European Robin and the gardener, as it reminds me of my childhood helping my father in our vegetable plot.

Some notable changes are the split of Black-capped, Flame-throated and Black-crested Bulbul, Common and Indian Blackbird, Dusky and Naumann's Thrushes, Rufous-throated and Black-throated Thrushes, Red-tailed Wheatear into Chestnut-rumped Wheatear and Rusty-tailed Wheatear. [Red-rumped Wheatear is renamed Buff-rumped Wheatear]. Some notable non-changes are Common Stonechat [a few possible splits], Mourning Wheatear and Arabian Wheatear and Common Scaly (or White's) Thrush and Amami Thrush, which remain lumped.

A few of the illustrations are a bit over-saturated. This is most evident in the Cedar Waxwing. This bird has a delicate and elegant colour scheme and is not as

bold as shown. The American bluebirds are a trifle too intense as are a few others, but most plates are accurate and certainly none would hinder identification.

Handbook of Birds of the World 10 adds another block of useful information to the world's ornithological literature for some of the world's most well known and loved birds. It is presented as readable text with

accurate and beautiful illustrations, complemented by excellent photographs. This is a mine of quality material that will be useful to many, especially the travelling birder – to be left at home as it is too large to pack.

ROY JOHN

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Handbook of the Birds of the World Volume 12

Edited by Josep del Hoyo, Andrew Elliott and David A. Christie. 2006. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 800 pages. 205 Euros. Cloth.

Kevin J. Caley is not a name that leaps into my mind when I think of paleontologists. He is the author of the foreword on fossil birds in this, the latest volume of *Handbook of Birds of the World*. He is an evolutionary biologist at the University of Nottingham, teaching various biodiversity-related subjects with a special interest in bird evolution and diversity. It was refreshing to read an article about the smaller dinosaurs and proto-birds rather than the giant flesh eaters. Caley has written and illustrated a comprehensive summary of the fossil record, covering 200 000 mya [million years ago] to 3000 mya. His illustrations are very helpful in following the evolution of species [although I question his relative size of his bald Velociraptor – about 7 m [43 ft.] compared to his Tyrannosaurus. This owes more to the film “Jurassic Park” than reality. [Velociraptor was turkey-sized 2 m and feathered]. The author includes a map of all major fossil sites [not bird fossil sites]. Both Alberta and Mongolia are missing. Similarly paleontologists like Phil Currie, Dale Russell, and Dong Zhiming are missing from his references.

This edition goes from Picathartes to Tits and Chickadees and includes Babblers, Parrotbills, Australasian Babblers, Logrunners, Jewel-babblers, Whistlers, Australasian Robins, Fairywrens, Bristlebirds, Thornbills, Australian Chats, Sittellas and Australasian Treecreepers. It covers a total of 638 species, a large proportion of which are Australasian. As in previous volumes, there is an introduction to each family covering systematics, morphology, habitat, behavior, voice, food, breeding, movements, relationship with man, and status and conservation. Each species account includes all the pertinent information about the biology of the bird. I checked through a host of species and found the taxonomic status is current, even if I get confused by the constant changes. I find it hard to reconcile the 59 subspecies of the Golden Whistler with the less-variable Blue Tit that has been split from the Canary Blue Tit. I also believe the distributions are accurate and the illustrations are correct. They cover every species and the more distinctive subspecies. I particularly noted how precise the Tawny-bellied Babbler – a recent life bird – illustration represented the birds I saw.

Considering there are 12 ornithologists who contributed to this volume, the quality of the accounts is both high and even. This is a credit to both the authors and editors and speaks volumes about their editorial discipline. There are 400 colour photographs, which range from good to spectacular. Again this is a reflection of the professional work done by the editors. For me, several photographs have a special appeal. The photograph of Great Tits [page 669] on a branch with catkins is given extra charm by the close match of the catkin colour to the yellow breasts of the birds. The photo of the Red-tailed Laughing Thrush [page 97] is not only a superb photo, but the birds themselves are very vibrant. Several other photographs also caught my attention [Splendid Fairy Wren [page 503], Varied Sittella [page 639], and Crested Tit [page 666]. The one that really grabbed me, though, is the photo of a Black-capped Chickadee hovering below a long icicle drinking. It took me a few moments to realise just what I was looking at, but when I clued in I was stunned.

I often wonder how prohibitive the cost of 205 Euros [about \$300 CAD] for each volume and about 2000 euros [almost \$3000 CAD] if you buy all 12 volumes. Remember there are more to come. For this money you could purchase 60 to 100 books on individual families. You would need to buy that many books to reference all of the families covered to date. For non-academic readers, the price of a volume may appear steep. However, it is reasonable when compared to the large number of other books you would have to buy to get the same coverage.

I have heard criticism about the brevity of the index – 17 pages for a book of 798 pages or 2%. I do not consider this out of line with similar books. While this might be an issue for academic researchers and possibly graduate students, for most of us the index is fine. While it is not detailed on technical terms, it does list all the species. I do not look for explanations of neontology [I would choose a more appropriate text]. I do expect to find the current known range of the Southern Emu-wren – and this index works well.

So once again Lynx have provided an impressive resource which will allow the enthusiast to go back frequently for much needed information on species splits and distribution.

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The Wisdom of Birds: An Illustrated History of Ornithology

By Tim Birkhead. 2008. Greystone Books, 2323 Quebec Street, Suite 201, Vancouver, British Columbia. 433 pages. 45 CAD. Cloth.

When I was in my teens, I collected plants. On my bike I used to scour the deserted roads of wartime Yorkshire in search of new finds. I was abetted in this lunacy by my parents, who had unearthed a vast 1888 tome, detailing every published report of every plant species in West Yorkshire from, it seemed, the beginning of time. One day I came across a very rare cinquefoil near a neighbouring village, and eagerly checked its status in this catalogue. To my astonishment the species had been recorded for this same location by the great botanist, John Ray, in 1670. It was still there! The effect was magical – I was no longer just an isolated kid with a weird hobby, but part of a proud tradition that went back almost 300 years!

It turns out that Ray did far more than publish a plant catalogue, noteworthy though that achievement was for its time. Unknown to me – and likely to most of the readers of this review – he went on to produce two books that laid the foundations for modern ornithology, and in this totally fascinating book Tim Birkhead argues Ray was the most influential ornithologist ever.

Histories have an image of dry-as-dust recitations of dates and names, but in essence science is about ideas. It is the history of the ideas that have influenced ornithology that Birkhead explores here, and at times there's more of the element of a detective story than a dull recitation to his account. He doesn't hesitate to use colloquialisms to make his point; you'll find the odd sentence without a verb, but his meaning is clear and his account is consistently lucid.

Nine broad topics, each the subject of a full chapter and together covering much of ornithological thought, form the body of the book. These range from the egg and its development to reproduction and longevity. For each, Birkhead looks at key questions: in the case of the egg, what was the origin of the new life, why do birds lay hard-shelled eggs, and how did the new life develop? He uses Ray as a starting point, as one of the first to ask the questions, capturing well the difficulty he and his contemporaries had in dealing with the com-

plicated problems they presented, and then traces the work that eventually led to the answers. Many of the issues discussed were not resolved until well into the last century, and indeed the answers to some of the questions preoccupied the ornithological community for much of the 1900s.

Such topics, then, will be familiar to ornithologists and others interested in the field. But Birkhead provides broader insights, giving interesting and valuable additional context to the subjects he discusses. While one might be familiar with the work of, say, David Lack, here Lack's work is presented as part of an expanded framework, showing its historical foundations and some of the issues that arose at the time he was active.

The opening and closing chapters bracket the rest of the book with an account of Ray's work and life. Together they form an excellent basis and fitting conclusion for the body of ideas in between.

The book's references, together with notes on the text, are gathered into 20 pages of notes at the back, together with an 18-page bibliography and a short glossary. There is an extensive and [as far as I could see] accurate index, plus an assortment of picture credits, biographical information and information on the type also gathered at the rear.

The illustrations deserve a special comment, as they are mainly reproductions of work by early artists, some occupying double pages – and some of these for no apparent reason! Apart from a few photos, only one painting by David Quinn was able to evade the seeming embargo on work later than the early 1900s. This approach seemed rather contrived, but nevertheless most of the plates were relevant and fit the historic theme, while providing an opportunity to see work that would be unfamiliar to many readers.

This is a wonderful book that discusses difficult concepts in a clear and readable way, and offers an insightful view of the history of ornithology. Highly recommended.

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Central Park in the Dark – More Mysteries of Urban Wildlife

By Marie Winn. 2008. Farrar, Straus and Giroux, 18 West 18th Street, New York, New York 10011 USA. 304 pages. 25 USD Cloth.

I'm not normally a fan of this type of book, but Winn's newest was indeed a pleasure to read. The chapters are laid out almost like a series of adventures, albeit tame ones compared with the sword and sorcery genre which I do follow. Unlike books in the

latter category, Winn's book does not include a map on the endpapers, ergo, the biggest drawback of this book is that Winn either assumes that the only people who will read this book frequent Central Park, and don't need a map, or somehow that all the geographic names she mentions really aren't important (then why mention them?). A map would allow the reader to keep track of where Winn, and her shifting bands

of co-adventurers are meandering somehow, understanding their locale, and their movements, would add so much to this book.

Like any good naturalist, Winn keeps notes, not only of what she saw, but where and when. Most of this information is transferred to the book, though uncharacteristically, the years of the observations are not. Some will find this a weak point, I didn't. After all, in the short time span (a few years) of her observations, there will not be much change from year to year. Additionally, this book is a non-fiction, natural history-based storybook, not a formal repository of scientific data, so I personally don't see any disadvantage of not recording the specific years here.

Readers of this book may come out with the idea that it is largely about the owls of Central Park – the wintering Long-eareds, the single Great Horned, the waxing and waning Eastern Screech-owls. I don't think so; this book is largely about the adventures of Winn and her colleagues to search for, monitor, and sometimes rescue these owls. As with many adventures, finding the target is only the satisfying end – the stories Winn tells are about the people and the interactions both among themselves and with their quarry. The owls give them purpose, but the stories are about the Central Park naturalists.

Many naturalists can point to one field trip, or one incident that turned them on to a particular field of natural history. "Bug Night" turned Winn and her colleagues into moth-ers (rhymes with "authors"). Read-

ers will reflect on their own personal moment when they became more than just a birder or amateur astronomer (or even a non-naturalist), and expanded their scope of interests to include bees, orchids or slime moulds. And this is part of the power of Winn's book – we share in the past adventures of the Central Park naturalists, including those pivotal life-moments, and simultaneously recall similar adventures of our own.

Much has been written about this book already, and invariably, the slug sex episode is brought up. In truth, it's a very small (but obviously charismatic) part of the book – I think included simply to describe something other than moths and owls, and as a bit of suspenseful comic relief. What really is confusing is that two-thirds of the one so-named chapter deals with cicadas and the wasp that feeds on them (the cicada killer) further proof that all the slinging, entwining, hermaphroditic gastropod encounters were just a segue between insects and birds.

Winn's book, as I see it, provides us with two important messages. One is that even in the depths of the largest cities like New York, there can be many natural wonders to experience. Second, the night is open to us to explore, sometimes through a telescope, sometimes through binoculars and sometimes through a jeweller's loupe. All we need now is a field guide to nocturnal nature.

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Ecology and Conservation of the Birds of the Salton Sink: An Endangered Ecosystem

Edited by W. David Shuford and Kathy C. Molina. 2004. Cooper Ornithological Society. c/o Western Foundation of Vertebrate Zoology, 439 Calle San Pablo, Camarillo, California, USA. 17.00 USD Paper.

The Salton Sea has long fascinated me. I have never seen it but it exists in my mind as a murky, sweaty spot where water melds with sky in the hazy distance, where rusted structures and dead trees perch along its salt-encrusted shore, where anarchic communities like Slab City show us our future. A quick Internet scan reveals it to be a handy metaphor, a swirl of contradictions and agrochemicals, much beloved and reviled, a birding hotspot, a vital migratory stopover on the Pacific flyway, and home of a National Wildlife Refuge named after Sonny Bono. The ecology and conservation of its biota, it seems, are a major part of its intrigue.

The Salton Sea sits in the Salton Sink, a basin whose complex history is integral to this work, which is number 27 in the *Studies in Avian Biology* series of the Cooper Ornithological Society. It is a compendium of 16 scholarly papers forming the proceedings of two symposia on the subject held in California in 1997 and 2000. The papers cover several themes: the biogeophysical history of the region, the extreme human im-

pacts upon it, the history of ornithology, the ecology and populations of the many bird species found there historically and now, and a conservation-oriented prescription for the future. The first two themes arise in practically every paper, for one can hardly discuss any aspect of the present ecosystem without reflecting on its colourful past.

Situated in the northwest-southeast valley system extending from the San Bernardino Mountains to the Gulf of California, therefore straddling the U.S.-Mexico border, the Salton Sink sits below sea level and contends with Death Valley as the hottest place in North America. At the northern end of the Colorado River Delta Region, the sink historically and prehistorically contained an ephemeral lake periodically filled by the flooding Colorado River. In more recent times dams and diversions have stifled the Colorado's flow. One last flood event in 1905 created the lake that is now the Salton Sea. However, instead of drying up as it had formerly done, it is replenished by runoff from irrigated agricultural fields. Whether in spite of, or because of this contribution, the Salton Sea is now 25 per cent more saline than the Pacific Ocean. But this is a simplistic summary. The editors' introductory paper, as

well as the paper "Linking the Salton Sea with its past: the History and Avifauna of Lake Cahuilla" will give you a much more thorough context-setting. We learn of the significance of the Salton Sink not only to its immediate surroundings but as a piece of the Colorado River Delta Region, itself radically altered over the last century.

As the authors of "History of Ornithological Exploration of the Salton Sink" point out, thanks to a strong naturalist tradition among earlier visitors to the region, studies began there before the present Salton Sea was created. This paper, and "Population changes and biogeographic affinities of the birds of the Salton Sink, California/Baja California" express the status, ecology and changes over a remarkably compact time period. The permanent water body has been in place for only 100 years, and ornithologists have been observing there, to varying degrees, for most of that time.

The Salton Sink is important for its locally breeding species (it hosts several regionally significant species and subspecies); as a migratory stopover or wintering territory for huge numbers of landbirds, waterbirds, waterfowl and shorebirds; and for its numerous records of vagrant or visiting pelagic and waterbirds via the Gulf of California. Not surprisingly, wetlands and associated species account for much of the focus of these papers. However, all bird groups present get some coverage, including landbirds with their dependence on riparian zones, and Burrowing Owls, whose population rose as land was converted by irrigation from Sonoran desert to agricultural.

Two additional papers discuss disease patterns: type C avian botulism, and the largest as-yet documented die-off of Eared Grebes which remained, at time of

publishing, unexplained. Avian cholera was present in some birds, high amounts of contaminants in others, but nothing had yet satisfactorily accounted for the extent of the die-off.

In the final paper, "The Salton Sea: A Conservation Conundrum or Paradigm for Success?" the editors discuss just that: do the region's complicated past and present mean it will ultimately be impossible to restore and maintain a healthy ecosystem, or is this a living laboratory leading to a model that can succeed here, and elsewhere? There remain many problems to solve, they admit, and all manner of social and political challenges.

As a compilation and analysis of baseline and other studies, this work should be an important part of the scientific literature for the region. It would also serve, if not as a model, at least as a reflection piece for environmental conservation workers anywhere, and certainly in locations analogous to this one, wherever they may be. The volume is consistently edited, the papers well-written. Although technical, they are not loaded with jargon. Abstracts are in English and Spanish. The citations from all the papers are combined in one "Literature Cited" section, making a very handy, comprehensive bibliography. One expects this type of work to be aimed at scientific and other professionals, but given the diverse interests in this region, with its large, transnational population and vanishing natural habitats, I believe it is a great service that this collection is readable enough to engage a curious and concerned public as well.

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Amur Tiger

By D. Pryn, Russian Nature Press (<http://www.rusnatpress.org.uk/>). 200 pages. 33 USD.

This very nice book gives great and entertaining information on the fascinating Amur Tiger. It is devoted to the great Russian naturalist and tiger expert: E. N. Matyushkin. This well-written and balanced text shows that this wildlife and conservation subject is a rather complex one: it deals not only with the vast Soviet Russian history, but also with today's Russia, with China as well as with a diverse set of stakeholders, including American and industrial ones (e.g., NGOs [non-government organizations] supported by Exxon Mobil and Shell; complete list is given in the Appendix). Interspersed with biological details are the nice and fascinating translated Russian writings by V.K. Arseniev, N.A. Baykov and others about Amur Tigers, their habitats and haunts (just the authors of these text sections alone are already worth several books). Amur Tigers live primarily in the Primorye region, Russian Far East, with Sikhote Alin and Amur river as its core, and the bordering China and North Korea region. This

region is part of the Pacific Rim and offers a unique biodiversity with many endemic and fascinating species (the mountain range of Sikhote Alin has over 1000 plant species for instance).

The English author is familiar with these subjects and presents us a well-balanced text and scholastic tiger information.

This book makes for a great case that western-style development is in direct conflict with splendid animals like the tiger. China's tiger population is already on the verge of extinction, and all Tiger populations world-wide are either extinct, or significantly reduced in their distribution and population. Only the Russian stock is the largest, and currently somewhat expanding (urbanization, global warming and intense resource use in this region are making its fate worse though).

This informative book focuses also on traditional tiger biology and habitat descriptions. I like the sections on prey, which support the case to consider the entire food chain and ecosystem for a meaningful conservation management. The text makes for a nice and

easy to read monograph, bringing the Russian Far East and its environs closer to a wider audience. This further gets achieved by the nice drawings and maps (no photos though). The four Appendices help to reach this goal further. I really appreciate the 16 pages of Notes. The presented literature is more from mainstream magazines, but it sufficiently allows the reader to get started on the topic.

The authors make clear that the Chinese tiger management policy, only focusing on captive breeding (e.g., at the breeding station in Harbin), but ignoring virtually all habitat issues, is more than dubious. The demand for tiger parts for Traditional Medicine gets widely cited for declines ('Operation Tiger' confiscated over 5000 snares in one campaign alone).

There is one flaw with this book: it does not make the direct link to the real problem in most carnivore and wildlife conservation: Traditional-style Economic Development, such as promoted in Russia, China, and most parts of the world these days, e.g., via the Asian Development Bank, will finish off the splendid tiger. For instance, the prey-base for these animals is already not sufficient, nor are the currently protected zones. Hydro-dam projects are not mentioned by the authors (a major issue in the Amur River basin), nor is

climate change. China just got granted two Russian islands in the Amur basin for their economic development, and the incredibly high Chinese demand for wood – the highly valued Korean Pine (*Pinus koraiensis*) – already widely cited for greatly contributing to habitat loss for tigers and their prey. Further problems occur through massive poaching and other development efforts. It is unclear to me why the Russian Government, one of the leading oil and gas producers in the world, and thus equally as rich as Saudi Arabia, is not able to support science-based Tiger conservation, and requires international assistance from NGOs and experts. Why does the international community let this happen?

This nice book should at least be read by every naturalist interested in Russia, Asia, wilderness, carnivores and cats. In times of globalization, it brings us one of the ten largest river systems – its ecosystem and wildlife – and with the tiger as its flagship species, closer to home.

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BOTANY

Woody Starch Plants in China

By Xie Bixia, Xun Chen, Donglin Zhang, Wenbin Liang, Qiuping Zhong, Sen Wang, Riqing Zhang, Anping Li, Xiaofang Pan, Yafeng Wen, Hongwen Zhuang, Tao Wu, Zhanying Gu, Xinjian Wang, Jiangfan Yu, and Manhui Hu. 2008. Science Press, Beijing, China. 360 pages, 88.00 CNY.

Starch (amylum) is a complex carbohydrate, a polysaccharide made up of a large number of linked glucose molecules (monosaccharides). In plants, starch is a by-product of photosynthesis, being mainly composed of two types of glucose polymer, the amylose and the amylopectin. It is an important and effective means of storing excess glucose as the form of energy for future use for the majority of plants. Starch, as an insoluble material, usually is stored in plant cells without impact on the water potential of cells, and thus may be stored in large amounts without disrupting the water potential of the cells. In plants, starch usually exists in the form of organized grains of various sizes and shapes, depending on the species of plant.

The primary production of plants forms the base of food chain or web of an ecosystem and fuels the whole ecosystem. Consumption of the primary producers by the heterotrophic organisms, and then transference of these organic molecules as well as the energy stored within them up the food chain or web, results in the energy flow of the ecosystem. In the whole process,

starch as a form of energy storage plays important roles. Starch is the major form of carbon reserve in plants, especially in the fruits, seeds, rhizomes or tubers. Some net primary production containing starch will go towards growth and reproduction of the primary producers, while some other parts will be consumed by herbivores. In some important starch plants, a category of plants containing abundant starch, it constitutes 50% or more of the dry weight of many storage organs. Starch must first be converted to a soluble form before being used by the plant itself, but if used by the heterotrophic organisms, it can be digested directly.

The lives of human beings are closely related to various types of plants, among which the starch plants are particularly important since they usually act as the source of daily food or industrial materials. Although the woody starch plants are not popularly used in the daily lives by human beings as much as some agriculturally important starch plants (most of them are graminaceous plants), some of them are frequently, or at least sometimes, consumed. Many woody starch plants still remain as wild plants, unexploited or even undiscovered, while only a few species have been exploited and used by human beings. Most of the woody starch plant species must have, or potentially have, value due to their abundant content of starch. Since the wild woody starch plants are usually pollution-free,

nutrient-rich, and at least some of them have a good taste or can be used as both food and medicinal plants, people all over the world usually like them very much. They also are saleable in the markets. In China, the use of woody starch plants have been used for a long history; however, due to the unreasonable use and immoderate picking, the resource of wild woody starch plants is becoming exhausted or endangered.

Obviously, effective exploitation, use and protection of the increasingly precious and exiguous woody starch plant resources is pressing. This needs to be recognized and the background information, summarized in terms of the present knowledge and further detailed research carried out. The timely publication of the book *Woody Starch Plants in China* meets this demand in at least some of these aspects. This book is the first monograph on the woody starch plant resources and their present status in China. It is divided into three major parts, the woody starch plant resources, their cultivation and their processing. In the first part, a total of 21 families and 242 species of woody starch plants are described in detail, in terms their morphological characteristics, growth habits and distributions. Illus-

trative text and figures are given in contrast, which are particularly helpful for readers to recognize and identify the species. In the second part, the theories and techniques on sowing, seedling cultivation, silviculture, stand thinning and pest control of the main woody starch plants are addressed systematically and in detail. In the third part, the physical and chemical properties and the processing methods for the starch of different woody starch plant species are addressed. The book includes authors' research data accumulated over many years, and also the major research achievements of other Chinese scientists.

The book is well-structured, and with strong readability. The book is suitable for staff who engage in forest research, education, production, cultivation, management, exploitation, utilization or other persons who are interested in these fields.

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ENVIRONMENT

The Burning Season

By A. Revkin. 2004. Island Press, 1718 Connecticut Avenue, N.W., Suite 300, Washington, D.C. 20009-1148 USA. 319 pages. Not illustrated, 22.50 USD

This book is a timeless classic of environmental history. It presents the reader with the fight for the interior Amazonian rainforest, an area which represents one third of the world's rainforest. *The Burning Season* must easily be among the best biographies of the murdered main character: rubber tapper Chico Mendes. Being deeply entrenched with naturalists, he actually is in the same rank as Lech Walesa, Cesar Chavez, or Martin Luther King, applying Ghandi-style non-violence sustainability progress, approved for instance by Prince Charles, by leaders of UNEP (M. K. Tolba), as well as the Canadian, Dutch and Swedish governments of the time.

The captivating and well-investigated text is thorough, and nicely written for the naturalist, for the lay audience as well as for the science-minded environmentalist. It tells how one political lobby, the land-owning large-scale Brazilian ranchers, and organized in the UDR (Rural Democratic Union), fought a vicious war against the rainforest, and with the support of weapons and governmental subsidies to keep the land in an intensive farming scheme at all costs. If that schema failed, the UDR supporters simply burned the offices that held the records of the historic land titles or intimidated local decision-makers, judges and citizens oth-

erwise in order to get by. The UDR did not approve of the great Liberation Theology movement in the Catholic Church either, and thus serious pressure was also put on those church ministers.

The term "burning season" refers to the seasonal occurrence of cultivating forest land for agricultural purposes. Burning forest land goes back to the old-fashioned legal Brazilian concept that is based on the right of possession (where a squatter can acquire a paper title if the land is used and under harvest or similar agricultural operation; e.g., cattle, for over five years). Further, "Grilagem", a policy of grabbing false land titles, has been known for a long time as a convenient method to own land in wild Amazonia and beyond. However, the rubber tappers defend their rainforest against the ranching lobbies and their army of squatters hired to burn the land, turning it into cattle land eventually, once the soil nutrients are quickly eroded. The rubber tappers, with Chico Mendes as one of their main leads, fight this off via "Zapates": a local justice activity demanding illegal squatters to leave the rainforest in a non-violent fashion.

Revkin shows us in painful detail that Brazil has a sad track record of killings, torture and brutal regimes, including governmental censorship, dictatorship, and approved shootings of native populations. He summarizes vividly that Mendes is actually only one out of 48 rural workers and environmental union activists that got killed in Brazil during the last few decades.

The fact that the killings in Brazil are still not over with, and that the disputes are still raging, is well indicated by the events in 2001 and 2002 when two leading land reform activists were assassinated. Other realities in Brazil are that about one-third of the population live without plumbing, that the income pyramid is fully reversed, and subsequently, that the poor land squatters are a major force wherever they can get access to rainforests; e.g., via roads. Undeniable witness accounts provided by satellite images and Brazilian scientists such as Alberto Setzer and Tebaldi Tardin were initially ignored by Brazilian decision-makers.

Revkin provides us with a fascinating account that leads the reader eventually to the killing event of Chico Mendes in his own home in the small town of Acree (Rhodonia province). The concept that Mendes promoted sounded easy: Setting up a system of extractive reserves that provides natives, rubber tapers, rubber trees and brazil nuts, as well as the ecological services and all of the regional Brazilian biodiversity a space to live. Many of these reserves are centred around the *seringueiros* (~ established harvest regions of individual rubber tappers).

For his life-long efforts the highly acclaimed Mendes got several internationally prestigious awards (e.g., the Global 500 Award, the Better World Society Protection of the Environment Medal, and worthy mention in *The New York Times* front pages). The book's author shows us in a fascinating way how this local union leader promoting sustainable land use practices becomes promoted by NGOs abroad (e.g., Oxfam, Ford & GAIA Foundations, Environmental Defence Fund) achieving the status of an international icon. Many of these achievements were supported and helped by anthropologists (e.g., Mary Allegritti and Stephan Schwartzman) and by the international media (e.g., through the English film maker Adrian Cowell). Other Brazilian eco-celebrities such as Jose Lutzenberger (GAIA movement, and late Environmental Minister of Brazil) or Raimundo de Darro (German Environmental awardee) are also mentioned.

Amazonia aside, this book actually centres primarily on rubber, latex, and the rubber tree (*Heveia brasiliensis*), also called caoutchouc or "weeping wood" by the local Indians. Subsequently, the reader is presented with a fascinating in-depth overview of the rubber history, its commerce and extraction from the wider Belem and Manaus region, which are the natural hot spots of rubber booms. Revkin reminds us vividly that obtaining rubber was "among the most brutal forms of labor exploitation in modern history". From 1850 onwards, much of the rubber business in Brazil was already in the hands of the English and other European merchants, and it gave the western European countries a major head start when it came to industrialization (and its associated electrification). This is because back then only rubber could insulate electrical wires and produce tires as well as to waterproof coats and boots. But it was the English Kew Botanical Garden research-

er Dr. Clements Mackham who found, in 1900, a way to break the global rubber monopoly of Brazil. Instead of having to rely on wild rubber from Brazil, now rubber was produced in industrial plantations of Singapore of Southeast Asia, and thus, this ended the rubber boom in 1912. In turn it destroyed a large part of the Brazilian economy and that nation as a whole. Because this happened at a time when Brazil was already running its virtual coffee monopoly at maximum capacity, the country could not grow any further and compensate. Consequently, Brazil was forced to borrow money from banks abroad, including from UK ones. The international borrowing scheme then set Brazil's path towards a development country with tragic national consequences, including the rise of a civil war led by Luis Carlos Prestes (supported by Moscow), military coups and major dictators and politicians such as the infamous Getulio Vargas. But a sudden need for rubber for the western armies during the second World War, and together with the associated Japanese threat to Singapore, Brazil became very interesting again to the U.S. government, which then further interfered with Brazilian politics.

The author reminds us vividly in this well-crafted read that various international influences overruled Brazilian politics. For instance, German Volkswagen in Brasil affected not only the car market but also helped to push for more roads. The U.S. company Dow Chemicals widely promoted Tordon, a herbicide to defoliate forests in favour of cattle ranches. And Japan became once more a driver for some Brazilian politics: it planned to build the access road "Highway BR-364" via Peru to western interior Brazil to obtain access to Amazonia, which then affected much of the environment Mendes worked in.

In its 13 chapters, the book covers well the tropical biodiversity, explaining the tropical ecosystem, pollination of brazil nuts and sustainable growing of cashew, cocoa and mahogany trees. Less than 2% of Amazonian plants are actually studied, yet. Such facts are apparently ignored by the World Bank and the Brazilian government alike. Because, and as the 319 pages convincingly show, Brazil offers textbook examples of environmental management and Mega-projects gone wrong. The conflicts caused by FUNAI (Fundacao Nacional do Indio, National Foundation for Indians) are mentioned, such as the infamous Ticunai tribe conflict vs. mahogany, and the Yanomami. Further, the human footprint in Brazil is huge, and the "Brazil Wood", for instance, is by now virtually extinct. Mega hydro-electric dams at Tucuri, or the largest iron ore reserve in the world (Serra dos Carajas), the Trans-Amazonian highway, or the Belem-Brazilia highway are mentioned as good examples. Another major initiative with massive negative environmental and socio-economic disasters was Polamazonia: Fifteen zones set up with help of the World Bank were to attract people with mega projects into selected target areas (Polonoroeste was described by the author as a worst case example). It

makes a virology textbook case that the spread and increase of deadly strains of malaria in South America were brought by these projects and deforestation.

Ultimately, this fight for land that made Mendes so famous is a fight for global sustainability, minorities, environmental justice, ecology and science-based management. Currently, Brazil is still not achieving this goal, and the killing of Chico Mendes left us with stunning evidence of their failure.

This book leaves little to be desired, although some readers might be eager for more photographs and an index. The 14 pages of notes, appendices and resources

make it a well-rounded standard text to be used in environmental history courses. With global climate change, globalization and a globally uncontrolled economic growth policy on the rise, one would wish we would breed more Chico Mendes types (e.g., in China, India, Russia and OECD countries), to halt and reverse the ongoing global habitat destruction folly.

FALK HUETTMANN

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Ecology

By Michael L. Cain, William D. Bowman, and Sally D. Hacker. 2008. Sinauer Associates, Inc., 23 Plumtree Road, P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. 621 pages. 130 USD Cloth.

There is arguably no scientific discipline more diverse than ecology. This presents a serious challenge to anyone faced with teaching this subject at the undergraduate level. With their book *Ecology*, Michael Cain, William Bowman and Sally Hacker have risen to this challenge. Lavishly illustrated, and thoughtfully written, this book strikes a good balance between information content and accessibility, and I expect it will serve admirably as an introductory textbook.

The first section presents the physical and biological framework for life on earth: climate, physical environment, and biosphere. I was pleased to see they have included a chapter addressing the connection between ecology and evolution. The two disciplines have long been treated as separate domains within biology, but the distinction is more cultural than biological. Some of the most interesting recent work in either discipline is focussed on developing new ways to integrate evolutionary data in ecological analyses (and vice versa).

Subsequent sections are devoted to population ecology, including life history analysis; interspecific interactions, with separate chapters covering competition, predation, parasitism and mutualism; community ecology and biogeography; ecosystem ecology; and applied and large-scale ecology, including conservation biology, landscape ecology, and global ecology. Some of the material, particularly in the first section, is likely to overlap substantially with other lower year courses in biology and geography. However, having it all together in a single book provides the instructor with some flexibility in terms of the required background and review material for students. Each chapter begins and ends with a case study, providing context for the more conceptual content. The examples are generally fairly recent, taken from studies published in the last 10 years. The text itself is clearly written, and accompanied by eye-catching illustrations that clarify and expand on the prose. The authors boast that the illustrations stand on their own, and tell stories that can be

understood without the accompanying text. This is indeed the case, and I enjoyed flipping through the book simply to look at the photographs.

In the preface, the authors state their two core principles were "Teaching comes First" and "Less is More". They have succeeded in sticking to their principles, without watering down the product. I was initially put off by the colourful page layout, as I assumed it meant that substance had been sacrificed for presentation. Happily, this was not the case. They manage to cover the core issues in each chapter with enough detail and illustrative examples to convey the message, but without overwhelming the reader with information. Each chapter is about 30 pages, and easily digested in a single sitting. They conclude each chapter with a list of suggested readings, which includes a good mix of classic texts, recent reviews, and key papers from the primary literature. This should satisfy motivated students, or provide material for class assignments.

Additional material is provided on a website devoted to the book, most of which is publicly accessible. Most notably, this includes additional empirical examples with questions suitable for use in a lab.

I would be quite happy to use this book as a textbook for a first or second year course in ecology. It doesn't provide enough depth for an upper year ecology course, however. The mathematical content is generally quite low. While this makes for a less intimidating introduction to ecology, I wonder if we do our students a disservice by shielding them from the complexity of ecological theory until after they've already forgotten their calculus. The publisher offers this textbook bundled together with Gotelli's *A Primer of Ecology*, which is more mathematically oriented, and additional theoretical detail is provided on the website. At \$130, this book is likely out of the price range of most amateur naturalists. However, birders or botanists interested in the science of ecology would certainly find this an accessible introduction to the topic, as would non-biology students.

TYLER SMITH

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MISCELLANEOUS

Wissenschaftler in turbulenten Zeiten: Erinnerungen an Ornithologen, Naturschuetzer und andere Naturkundler [Scientists in troubled times: Memories about Ornithologists, Conservationists and other Naturalists]

By E. Nowak. 2005. Stock & Stein Publisher, Schwerin, Germany. 432 pages. Cloth.

This unique biography book on famous naturalists will make you shiver: If you ever wonder why even great researchers did not get acknowledged, promoted and tenured, read this book. As a monument in time, it is of great value to the general public, to old and to young scientists alike. It is for that reason that I decided to present an English review of this book (as this great book currently only exists in German; Russian translation is planned by the book's author).

In this fascinating publication author E. Nowak presents us with a unique documentation on how politics overrule and interfere with (bird) science and conservation world-wide. Denial of jobs, rejected manuscripts and books, censorship, and personal tragedies are rather familiar to the 15 Germans, 14 Russians, 8 Polish, 2 French, 2 Koreans, as well as Austrian, English, Danish, Czech, Ukrainian, Bulgarian, Chinese, Indian and American scholars of natural history from the 19th and 20th centuries. The book index actually mentions over 700 individual researchers overall and they are directly related to the scholars described. Nowak knew virtually all of them personally, and many stories he compiled are tragic, some end on a somewhat positive note, but all basically tell a story of incredible endurance, persistence, complexity and hard scientific labor; it's for the birds.

As the 432 pages tell us eloquently, even the most famous researchers experience removal from committees, from editorial jobs, and from publication and lecturing at universities. V. Wahl for instance, an inspiring ornithologist from Czechoslovakia, was simply executed 60 years ago because his political opinion was just not "*en vogue*". Regular prison, war camps, gulags, concentration camps, as well as deaths, tragedies of family members, and suicides of many (bird) scholars and even Ph.D. students are listed in much detail.

The author, E. Nowak, cannot deny his distinctly Polish view when sharing with us his personal accounts of these individuals. But although this book describes mostly the Central European situation (Eastern European Communism, Nazi-Germany) it deals well with England, Korea, New Zealand and also with political giants and their regimes such as Russia, India and China. It captures world history.

Some of the core themes of this book might be G. Niehammer's pro-Nazi work (e.g., his infamous *Observations of the Avifauna of Auschwitz*), H. Kumerloeve's research career during the Third Reich and his continued support by the DFG ("Deutsche Forschungsgemeinschaft"; the German Science Foundation) after

the war, E. Schaefer's SS ("Sturmstaffel", Germany's infamous Interior Military Police during the Third Reich) support, and the East German H. Dathe's history with the NSDAP ("National Sozialistische Deutsche Arbeiter Partei"; Hitler's Nazi Party). The proud statement from Nobel Prize winner K. Lorenz "*we Austrians are the best Nazis of all*" might serve the reader as a representative impression of such details. Nowak presents us with the rhetorical question: can we really judge these historical situations and circumstances?

What excites me here is less the party membership issues of relevant ornithologists and scientists of the day, but much more the inherent cultural publication bias that comes with such and closely related scientific value-systems (e.g., stark nationalistic, white race, male and hierarchical world views in ornithology and beyond), and which are still slightly obvious to this very day (e.g., in the German Journal of Ornithology; I also do not understand why the author does not criticize F. Tischler, for instance, nor the German DO-G Deutsche Ornithologen-Gesellschaft; Germany's ornithological society).

"Nerds with binoculars", such as ornithologists, always raise suspicion. Beyond R. Meinertzhagen and his suggested involvement in trying to rescue the Russia Tsar and his family, the notions of secret service and spying come up again and again in this book and form a chapter of its own. The infamous archives of the Stasi ("Staatssicherheit"; the security service of Eastern Germany using public informants and violating human rights) get cited quite a bit (e.g., in the case of E. Rutschke, H. Stubbe, W. Makatsch and H. Dathe). We learn in this book as well that the well-maintained Archives of the Russian KGB/NKWD, another global heritage by now, have still much information to offer and can be expected to provide us with many surprises for years to come. Further, the book's author points out to us some corrections on Russian researchers regarding views presented in the standard reference by Flint and Rossolimo (1999). This book is history in the making.

Myself, I found these 432 page to be a rather fascinating read, and my personal favorites are, by far, H. C. Johansen and B. K. Stegmann, or the fascinating lives of J. Delacourt, P. Pfeffer, K. Wodzicki, and the Jankowski family. Every naturalist should know about their achievements and life experiences. The book presents a foundation for ornithological textbooks, environmental history and "Wildlife 101" lectures. I am sure that the readers will for instance appreciate learning about Prof. A. N. Formosov, who helped to build in Russia one of the most extensive networks of

protected areas in the world (!), or about the paper by Prof. N. Gladkow on "*Lenin'istic Principles of Nature Conservation*" and that he even carried out bird work during the actual Stalingrad battle in World War II [WW2] fighting for the Germans. It's probably of further interest to the global audience to learn how the two zoological gardens in Berlin and their directors got involved competing for what is "the best social system and society in the world". The history of the RAMSAR Convention and its Russian foreplay (only disturbed last minute by the invasion in Prague) gets well described, too.

This book deals a lot with the Weimar Republic, the k.u.k. (Austrian-Hungarian) monarchy, WW1 and WW2, the Korean and Vietnam wars, as well as with Stalin, Hitler and Mao Tse Tung (relevant U.S. events are largely left out unfortunately). One really should disagree though with the value system Nowak frequently presents us with in the text: coming from a noble family is usually labelled as positive, hunting would be the accepted foundation for ornithology, being always well-behaved and soft-spoken is a must, being a tedious and obedient museum-based scholar is even better, working in a narrowly niched-in discipline is the norm, and always staying politically out of trouble would even be better. Such approaches to nature have not halted the global conservation crisis, though. It further sets the stage for a broken but entrenched peer-review system among buddies and insiders; not being performance-based nor embracing interdisciplinary approaches and harming global progress. Many national ornithological unions, trusts and societies still suffer from these very problems and have not moved on, virtually making global conservation problems worse, leaving their large potential unused.

This book further celebrates Old Boys Networks *par excellence*. However, many of the "Old Boys" were not short of devotion and publications either (E. Stresemann and N. Boew with over 700 publications, each; or G. P. Dementjew and N. Gladkow, who virtually took no week-ends and holidays) and many of them wrote landmark publications setting an odd foundation for a related bird and conservation culture to this very day.

Writing about other people's lives and tragedies requires skill, and is a major task and undertaking. Nowak masters this chore rather convincingly. However, constantly peeking in personal and governmental security archives and trying to find peculiar biographic details might be perceived by some as "Whistle-Blowing." One really would have wished this book would have provided us with insights into the German and other national academies of sciences, and their puppet-like strategies, involving political 180 degree changes throughout history and in recent times. That the so well-informed author politely ignores these things tells us at least something.

This publication actually makes for an oral history book. But Nowak, despite his claim on the book jacket, does not really follow the established rules of this discipline. Instead, Nowak leads us into his own world of what he picked up along the way while working and meeting with people in his diplomatic, international and scientific career, and from seven years of his own specific research. Therefore, this book carries much entertaining gossip. Another rather interesting detail, but mentioned somewhat aside, is presented by the fact that many of the "big names" and people doing fieldwork are either divorced, or marry their field work partner. What also would make for an interesting modern study subject is whether the people Nowak describes have experienced a peculiar mother-father relationship.

Regardless, this book makes a must-read and reference in your book shelf. In times of globalization, it's a unique historical document opening up new ways of thinking about (museum) ornithologists and even conservationists. Young scientists will be interested learning about the years of anxiety researchers had to go through; only few got rich and all worked incredibly hard. Due to all the political pressures and when working with internationally migrating birds, some scientists can indeed be described as Top-Managers "dancing frequently on eggs" and around research and import permits (e.g., in the case of W. Makatsch). The almost bizarre lives of scientists working abroad and between countries are well covered (W. Beick, W. Graf Dzieduszycki, E. Rutschke, W. Makatsch, K. Wodzicki, N. A. Gladkow, besides others).

Nowak makes it a common statement to his readers that parents of the described scholars usually tried to stop their children from becoming ornithologists or biologists. In regimes that turned violent, the professional repressions, as well as career blockage due to political reasons, family background and ideology occurred frequently. This is often played through lack of acceptances and transfers, or forced withdrawals, of university degrees and promotions. Freedom of speech virtually did not exist. It is shown that becoming a party member was often a must for many scholars.

The book shows that people with a personal opinion and strong will were not wanted, and lost their job (e.g., in the case of A. B. Kistiakowsky). It is further shown that "informants" commonly occurred. Betrayals by colleagues, even for Nobel prize awards, get described several times. Often, it's not the censorship as such, but the colleagues themselves and "the faculty" that carried out the pre-screening on behalf of the government then in power.

Unfortunately, the major role the U.S. plays in science and conservation (e.g., via the CIA, FBI and through "modern" commercial and foreign policies) is basically omitted by the author. However, it is mentioned that the U.S. paid for the 1930s German expe-

ditions for E. Schaefer and E. Stresemann (which basically set up both for their careers).

Finally, a book that describes how scientists of this world have been treated in our current time and by the "Iron Triangle" and the so-called "free Western World" still needs to be written (see Ott 2005 and Stiglitz 2005 for an initial introduction and overview). Appropriately, Nowak cites the ancient Greek philoso-

pher Sophokles (in *Hipponos*): "...hide nothing because the time sees and hears everything, and she will expose it".

FALK HUETTMANN

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NEW TITLES

Prepared by Roy John

† Available for review * Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

ZOOLOGY

† **The Archeology of Animal Bones.** By T. O'Connor. 2008. Texas A&M University Press, 4354 TAMU, College Station, Texas 77843-4354. 216 pages. 25.95 USD. Paper.

Beaver (Castor Fiber) in Slovenia/Bober (Castor Fiber) in Sloveniji. By B. Krystofek, A. Hudoklin and D. Pavlin. 2006. [In Slovenian]. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 41 pages. EUR 20.00.

Fifty Years of Flukes and Flippers: a Little History and Personal Adventures with Dolphins, Whales and Sea Lions – 1958-2007. By W. Evans. 2008. Pensoft Publishers, Sofia & Moscow, Geo Milev-Str., No 13a, 1111 Sofia, Bulgaria. 147 pages. EUR 20.00.

A Review of Phylogeny and Classification of Gerbillinae (Mammalia: Rodentia). *Zoologicheskie Issledovaniya* No. 9. By I. Pavlinov. 2008. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 68 pages. EUR 19.00.

The Dwarf Hamster Genus Phodopus: Systematics, Phylogeography, Ecology, Physiology, Behaviour, Chemical Communication (Khomyachki Roda Phodopus: Sistematika, Filogeografiya, Ekologiya, Fiziologiya, Povedenie, Khimicheskaya Kommunikatsiya). By N. Feoktistova. 2008. [In Russian with a summary in English]. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 414 pages. EUR 76.00.

Principles and Methods of Mammalian Age Determination (Printsipy I Metody Opredeleniya Vozrasta Mleko-pitayushchikh). By G. Klevezal. 2007. [In Russian]. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 284 pages. EUR 38.00.

The Musk Deer: Ecology, Numbers Dynamics, Prospects for Conservation (Kabarga: Ekologiya, Dinamika Chislennosti, Perspektivy Sokhraneniya). By V. Zaitsev. 2006. [In Russian, summary in English.] Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 120 pages. EUR 37.00.

Spatio-ethological Structure of Rodent Populations (Prostranstvenno-etologicheskaya Astrukrura Populyatsii Gryzunov). By V. Gromov. 2008. [In Russian]. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 582 pages. EUR 76.00.

Baleen Whales. Mammals of Russia and Adjacent Regions. By V. Sokolov and V. Arsen'ev. 2006. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 318 pages. EUR 45.00.

The White Whale, Delphinapterus Leucas, in Russia's Arctic Seas: Biology, Ecology, Conservation and Resource Exploitation (Belukha Delphinapterus Leucas Arkticheskikh Morey Rossii: Biologiya, Ekologiya, Okhrana I Ispol'zovanie Resursov). By G. Matishov and G. Ogetov. 2006. [In Russian, summary in English.] Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 296 pages. EUR 36.00.

The Wild Mammals of Wisconsin. Pensoft Series Faunistica 68. By C. Long. 2008. Pensoft Publishers, Sofia & Moscow, Geo Milev Str., No 13a, 1111 Sofia, Bulgaria. 524 pages. EUR 78.00.

BOTANY

* **Trees and Shrubs of Minnesota.** By Welby R. Smith. 2008. University of Minnesota Press Suite 290, 111 Third Avenue South, Minneapolis, Minnesota 55401. 704 pages. 59.95 USD.

OTHER

* **A Mountain Year – A Nature Diary of a Wilderness Dweller.** By C. Czajkowski. 2008. Harbour Publishing, Box 219, Madeira Park, British Columbia V0N 2H0. 176 pages. CAD 36.95. Cloth.

* **Snakebit.** By L. Anthony. 2008. Greystone Books, #201 – 2323 Quebec Street, Vancouver, British Columbia V5T 4S7. 288 pages. 29.95 CAD. Cloth.

News and Comment

Dr. Neal Simon Memorial Scholarship Award

The Dr. Neal Simon Memorial Scholarship Award was created in 2006 through the many donations of friends, family and colleagues of the late Neal Philip Perry Simon (1973-2006). The annual scholarship, valued at \$1000.00, intends on providing financial assistance to residents of Labrador pursuing a post secondary diploma or degree in the natural resources, ecological, biological or environmental fields. The awarding of the scholarship will be based on financial need; community and/or school volunteer activities academic ability and environmental conservation interests.

The first Dr. Neal Simon Memorial Scholarship was awarded to Ms. Samantha Joy Irene Churchill of Happy Valley – Goose Bay, Labrador in May 2008. Ms. Churchill, a graduate of Mealy Mountain Collegiate in Happy Valley – Goose Bay, intends on pursuing post

secondary studies in Biology at the University of New Brunswick (very fitting as Neal completed both his MSc. and PhD. at UNB).

Application information on the Dr. Neal Simon Memorial Scholarship Award can be obtained by contacting:

The College of the North Atlantic
Attention: Valerie Sheppard
Dr. Neal Simon Memorial Scholarship
P.O. Box 1720 Station B
Happy Valley-Goose Bay, Newfoundland and
Labrador A0P 1E0 Canada

Completed applications must be postmarked by 31 March each year. Any questions can be directed to Valerie Sheppard (709) 896-6306 or email valerie.sheppard@cna.nl.ca.

The Boreal Dip Net / L'Epuisette Boreal Volume 12, Number 1

Newsletter of the Canadian Amphibian and Reptile Network.

Contents: Editor's Note (Sara Ashpole) — Notes from the Bruce Pauli, Chairperson of the Board of Directors CARCNET/RECCAR (publisher of *The Boreal Dip Net*) — Joint Meeting of Ichthyologists and Herpetologists 23 to 28 July 2008 Montreal, Quebec — Student Presentation Awards at the 2007 Annual Meeting: Student Award for Best Platform presentation in 2007 — Jeffrey R. Row; Student Award for Best Poster in 2007 — Anita Melnyk; Silver Salamander Award for 2007 — Kids for Turtles (Peterborough, Ontario, area); Blue Racer Award for 2007 — Dr. David Green — Critical Habitat Workshop 2007 — Field Trip Synopsis 2007 — CARCNET/RECCAR 2007 Scholarship Winner — Julie Lee-Yaw, University of British Columbia — Plenary: The Long Evolutionary History and Challenge future for Frogs Salamanders

and Caecilians (Robert L. Carroll) — Plenary: Amphibians, Reptiles, and the Challenges of Multiple Environmental Stressors: Paleoenvironmental Approaches for Tracking Long-term Changes in Aquatic Ecosystems (John P. Smol) — CARCNET/RECCAR 2007 Annual Meeting Presentations (60 presentations by title and authors) — New IMPARA [IMPortant Amphibian and Reptile Area] Site: Cootes Paradise, in Hamilton, Ontario (Tana McDaniel) — The Transmitter (Short stories of herpetological experience) CARCNET/RECCAR Coffee Table Book/Most Memorable Herping Moment in Canada (David Cunnington) — International Conference on *Batrachochytrium dendrobatidis* (Purmina Govindarajula) — Help Wanted: Barcoding the Amphibians of Canada (David M. Green and Jean-Sebastien Roy) — Member Publications — Book Launch: Ecology, Conservation, and Status of Reptiles in Canada.

Marine Turtle Newsletter (120)

April 2008. 28 pages: ARTICLES: Loggerhead Turtle mortality from attempted ingestion of Porcupine Fish (C. J. Limpus, D. J. Limpus, M. Horton, and L. Ferris) — Fibropapillomatosis in stranded Green Turtle in Paraiba State, northeastern Brazil: Evidence of a Brazilian epizootic? (M. Mascarenhas and P.J. Iverson) — Sea turtles in Santiago Island, Cape Verde (N. S. Loureiro). Two new dive types with a gradual ascent phase in Flatback Turtles (*Natator depressus*) (J. B. Sperling) — NOTES: A case report of hook inges-

tion and expelling by a Green Turtle (M. R. Werneck, B. de Barros Giffoni, C. E. N. Consulim, and B. G. Gallo) — BOOK REVIEWS — IUCN-MARINE TURTLE SPECIALIST GROUP QUARTERLY UPDATE — MEETING REPORTS — ANOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS — ACKNOWLEDGEMENTS.

The Marine Turtle Newsletter is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab

Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <<http://www.sea>

turtle.org/mtn/> or postal mail to Michael S. Coyne (Managing Editor) Marine Turtle Newsletter, A321 LSRC, Box 90328 Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: mcoyne@seaturtle.org.

Canadian Association of Herpetologists / Association Canadienne des Herpetologistes Bulletin 15(2) Spring 2008

Contents: Instructions to Authors — Editorial Notes — Meetings — Feature Article: Ruminations on a possibly envenomating bite by a garter snake (Patrick Gregory) — Book Reviews — Thesis abstracts in Canadian herpetology (Valerie St-Amour MSc 2007 Laurentian University, Sudbury, Ontario; Supervisor David Lebarre; “Amphibian emergent infectious diseases: detection, anthropogenic effects and fluctuating asymmetry” — Josie Todd, MSc 2007, Dalhousie University, Halifax, Nova Scotia; Supervisor Richard Wassersug; “Towards developing a strategic recovery

plan: The behaviour and ecology of the Northern Ribbonsnake *Thamnophis sauritus septentrionalis* — Krycia Tuttle MSc 2007 University of Victoria, Victoria, British Columbia; Supervisor Patrick Gregory; “Natural history of the Plains Garter Snake *Thamnophis radix*” at the northern limit of its range in Alberta, Canada” — Janet Wood BSc Laurentian University, Sudbury, Ontario; Supervisor Jacqueline Lizgus; “Turtle movements and habitat selection in an urban landscape” — Recent Publications in Canadian Herpetology.

John Allen Livingston

John Allen Livingston, an Honorary Member of the Ottawa Field-Naturalists' Club since April 1997 (see *The Canadian Field-Naturalist* 112(3): 545) died 17 January 2006. Born at 10 November 1923 at Hamilton, Ontario, Livingston became an outstanding Canadian naturalist, broadcaster, teacher, and writer. He was the voice-over of the *Hinterland Who's Who* television series in the 1960s, professor at York University (1972-

1992), and prolific author: *Darwin and the Galapagos* (1966) (with Lister Sinclair); *Birds of the Northern Forest* (1966) (with J. F. Lansdowne); *One Cosmic Instant* (1968), *Arctic Oil* (1981); *The Fallacy of Wildlife Conservation* (1981); *Canada: A Natural History* (1988); and the Governor General's Award-winning *Rogue Primate: An Exploration of Human Domestication* (1994). [See: en.wikipedia.org/wiki/John_Livingston]

Eugene Gordon Munroe

Eugene Gordon Munroe, Honorary Member of the Ottawa Field-Naturalists' Club since April 1985 (see *The Canadian Field-Naturalist* 99(4): 547) died 31 May 2008 in his 89th year. Dr. Munroe was an ento-

mologist specializing in Leptodoptera at the Central Experimental Farm, Ottawa beginning in 1950 and continuing in retirement.

Errata *The Canadian Field-Naturalist* 121(1): 96

In “A tribute to Neal Philip Perry Simon 1973-2006”
First paragraph, seventh line, “where he resided since 1988”
Should read “where he resided since 1998”

Errata *The Canadian Field-Naturalist* 122(1): 40

In “Repeatability of foraging tactics in young trout, *Salvelinus fontinalis*”
The “present address” given for Peter A. Biro as the University of Alberta is in error as he will be remaining in Australia in order to accept an Australian Research Council Award for 5-6 years of dedicated research time.

Editor's Report for Volume 121 (2007)

Mailing dates for issues in volume 121: (1) 6 June 2008; (2) 6 November 2008; (3) 31 December 2008; (4) 20 March 2009

A summary of membership and subscriber distribution totals for 2007 is given in Table 1. The number of articles and notes in volume 121 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4.

The journal was printed at Gilmore Printers, Ottawa, and thanks are due business representative Tom Smith and customer representative Chuck Graham for overseeing production. Wendy Cotie typeset galleys and page proofs. Elizabeth Morton edited and proofed the galleys. Sandra Garland, the club webmaster, posted contents on the Ottawa Field-Naturalists' Club web site. Leslie Cody prepared the Index for volume 121. Duties of Business Manager were assumed by Treasurer Frank Pope assisted by Assistant Treasurer Jim Ward. Roy John requested books for review and selected reviewers, edited submitted reviews, and prepared the new titles listings. Warren B. Ballard rejoined the Associate Editors in 2007 after an absence of several years.

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 55 in 2007, a drop reflecting a backlog in publishing. The following reviewed papers submitted in 2007 (with number of manuscripts reviewed in parentheses if more than one): **Associate Editors:** R. Anderson, Canadian Museum of Nature, Ottawa, Ontario (2); W. B. Ballard, Texas Tech University, Lubbock, Texas (7); C. D. Bird, Erskine, Alberta (6); R. R. Campbell, St. Albert, Ontario; P. M. Catling, Agriculture and Agri-food Canada, Ottawa, Ontario (4); B. W. Coad, Canadian Museum of Nature, Ottawa, Ontario (2); J. Erskine, Sackville, New Brunswick (15); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (3); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (6); W. O. Pruitt, Jr., Uni-

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 121 (2007) by major field of study.

Subject	Articles	Notes	Total
Mammals	18	12	30
Birds	10	5	15
Amphibians + reptiles	2	1	3
Fish	3	1	4
Invertebrates	5	3	8
Plants	7	2	9
Other	2	0	2
Totals	47	24	71

versity of Manitoba, Winnipeg, Manitoba (9); **Others:** R. Alvo, Gatineau, Quebec; G. Arnweiler, Edmonton, Alberta; J. S. Bleakney, Wolfville, Nova Scotia; S. Boudrup-Nielsen, Acadia University, Wolfville, Nova Scotia; J. A. Burns, Royal Alberta Museum, Edmonton, Alberta; L. Carbyn, Canadian Wildlife Service, Edmonton, Alberta; W. J. Crins, Ontario Ministry of Natural Resources, Peterborough, Ontario (2); I. A. Crowder, Queen's University, Kingston, Ontario; K. M. Dickson, Canadian Wildlife Service, Environment Canada, Gatineau, Quebec; D. Evers, Biodiversity Research Institute, Gorham, Maine; J. Ferron, Université du Québec à Rimouski, Québec; A. J. Gaston, Canadian Wildlife Service, Hull, Quebec (2); D. M. Green, Redpath Museum, McGill University, Montreal, Quebec; P. T. Gregory, University of Victoria, British Columbia (2); M. Guillemette, Université du Québec à Rimouski, Québec; F. H. Harrington, Mt. St. Vincent University, Halifax, Nova Scotia; T. Herman, Acadia University, Wolfville, Nova Scotia; C. S. Houston, Saskatoon, Saskatchewan (3); H. Howden, Canadian Museum of Nature, Ottawa; R. L. Jeanne, University of Wisconsin – Madison; T. S. Jung, Yukon Department of

TABLE 1. The 2007 circulation of *The Canadian Field-Naturalist* (2006 in parenthesis). Compiled by Frank Pope from 121(4) mailing list. Forty percent of membership dues and 100% of subscriptions go to publication of *The Canadian Field-Naturalist*. Members vote on Club affairs, subscribers and institutions do not.

	Canada	USA	Other	Totals
Memberships				
Family & individual	544 (556)	25 (24)	5 (5)	574 (585)
Subscriptions				
Individuals	115 (131)	44 (57)	3 (5)	162 (193)
Institutions	197 (158)	224 (232)	33 (32)	454 (422)
TOTALS	856 (845)	293 (313)	41 (42)	1190 (1200)

Note: 22 countries are included under "Other" (outside Canada and United States).

TABLE 3. Number of reviews and new titles published in Book Review section of *The Canadian Field-Naturalist* Volume 121 by topic.

	Reviews	New Titles
Zoology	33	173
Botany	8	13
Environment	2	0
Miscellaneous	11	41
Young Naturalists	3	12
Totals	57	239

Environment, Whithorse, Yukon; S. Larivere, Cree Hunters and Trappers Income Security Board, St. Foy, Quebec; J. D. Litzgus, Laurentian University, Sudbury, Ontario; G. L. Mackie, University of Guelph, Ontario; J. Mager, Ohio Northern University, Ada, Ohio; F. F. Mallory, Laurentian University, Sudbury, Ontario; A. Martel, Canadian Museum of Nature, Ottawa, Ontario; J. Mather, University of Lethbridge, Alberta; L. D. Mech, U.S. Geological Survey, The Raptor Center, University of Minnesota, St. Paul (3); R. F. Miller, New Brunswick Museum, Saint John; Ralf Meisterfeld, Institute for Biology II (Zoology), Department of General Biology, Aachen; D. Naughton, Canadian Museum of Nature, Ottawa, Ontario; J. S. Nelson, University of Alberta, Edmonton, Alberta (2); L. E. Noel, ENTRIX, Inc., Anchorage, Alaska; G. Parker, Canadian Wildlife Service, Sackville, New Brunswick; J. Reddoch, Gloucester, Ontario; R. Rosatte, Ontario Ministry of Natural Resources, Trent University, Peterborough, Ontario; A. Russell, University of Calgary, Alberta (2); S. Boudrup-Nielsen, Acadia University, Wolfville, Nova Scotia; F. Scott, Acadia University, Wolfville, Nova Scotia (3); D. Seburn, Ottawa, On-

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist* Volume 121 (2007) by issue.

	(1)	(2)	(3)	(4)	Total
Articles	88	87	86	61	324
Notes	7	13	11	19	50
Book Reviews*	17	14	13	14	58
Tributes	4	0	0	0	4
CFN/OFNC Reports	**	0	3	8	4
15					
News and Comment	1	2	1	1	5
Index	0	0	0	21	21
Advice to Contributors	1	1	1	0	3
Totals	118	120	120	120	478

* Total pages for book review section include both reviews and new titles listings.

** Includes CFN Editors' report in (2), OFNC Annual Business Meeting (3) and OFNC Awards (4).

tario; Jacques Sirois, Falconeye, Edmonton, Alberta; K. W. Stewart, University of Manitoba, Winnipeg, Manitoba (2); D. A. Woolnough, Trent University, Peterborough, Ontario; T. N. Zimmerling, Applied Ecosystem Management Limited, Grand Prairie, Alberta (2).

I am also indebted once again to the President and Council of The Ottawa Field-Naturalists' Club and to Chairman Ron Bedford and the Publications Committee of the OFNC for continuing support, the Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Gatineau (Aylmer), Quebec, and to Joyce for general support.

FRANCIS R. COOK
Editor

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit manuscripts **written in the journal style by e-mail or on a CD by post to the Editor**, in either English or French. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be printed on standard-size paper, **doublespaced throughout**, generous margins to allow for copy marking, and **each page numbered**. For Articles and Notes provide a citation strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and **le Grand Larousse Encyclopédique** are the authorities for spelling.

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Photographs should be from prints with a glossy finish and show sharp contrasts. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Electronic versions should be high resolution. Author's name, title of paper, and figure number should be included on the lower left corner.

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Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

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FRANCIS R. COOK, Editor
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Book Reviews

ZOOLOGY: Handbook of Birds of the World Volume 10 — Handbook of Birds of the World Volume 12 — The Wisdom of birds: An Illustrated History of Ornithology — Central Park in the dark: More Mysteries of Urban Wildlife — Ecology and Conservation of the Birds of the Salton Sink: An Endangered Ecosystem — Amur Tiger	182
BOTANY: Woody Starch Plants in China	188
ENVIRONMENT: The Burning Season — Ecology	191
MISCELLANEOUS: Wissenschaft in turbulenten Zeiten: Erinnerungen an Ornithologen, Naturschuetzer und andere Naturkundler [Scientists in troubled times: Memories about Ornithologists, Conservationists and other Naturalists]	192
NEW TITLES	193

News and Comment

Dr. Neal Simon Memorial Scholarship Award — <i>The Boreal Dip Net / L'Epuisette Boreal</i> 12(1) — <i>Marine Turtle Newsletter</i> (120) April 2008 — <i>Canadian Association of Herpetologists / Association Canadienne des Herpetologistes Bulletin</i> 15(2) Spring 2008 — John Allen Livingston — Eugene Gordon Munroe — Errata	132
---	-----

Editor's Report for Volume 121 (2007)	FRANCIS R. COOK	196
---------------------------------------	-----------------	-----

Advice to Contributors	198
------------------------	-----

Mailing date of the previous issue 122(1): 15 October 2009

Articles

- Decline of two open Champlain Sea dune systems in eastern Ontario and their characteristic and restricted vascular flora and insects
PAUL M. CATLING, HENRI GOULET, and BRENDA KOSTIUK 9
- Habitat parameters and small mammal associations of the Gaspé Shrew, *Sorex gaspensis*, in the eastern Gaspé Peninsula, Québec
CHRISTIAN FORTIN and DENIS COMEAU 11
- Abundance trends for *Hexanchus griseus* (Bluntnose Sixgill Shark) and *Hydrolagus coliei* (Spotted Ratfish) counted at an automated underwater observation station in the Strait of Georgia, British Columbia
ROBERT DUNBRACK 12
- Anurans in a subarctic tundra landscape near Cape Churchill, Manitoba
MATTHEW E. REITER, CLINT W. BOAL, and DAVID E. ANDERSON 12
- Bullsnake, *Pituophis catenifer sayi*, nesting biology in Alberta
JONATHAN D. WRIGHT 13
- Reproduction and mortality of the high arctic Wolf, *Canis lupus arctos*, in northeast Greenland, 1978-1998
ULF MARQUARD-PETERSEN 14
- Les collisions d'oiseaux à l'édifice Marly, St. Foy, Quebec, de 1978 à 2000
YVAN POULIOT 15
- A localized decline in the Western Chorus Frog, *Pseudacris triseriata*, in eastern Ontario
DAVID C. SEBURN, CAROLYN N. L. SEBURN, and WAYNE F. WELLER 15
- Spatial and temporal differences in giant kidney worm, *Dictophyma renale*, prevalence in Minnesota Mink, *Mustela vison*
L. DAVID MECH 16

Notes

- Canada Lynx, *Lynx canadensis*, use of the Chignecto Isthmus and the possibility of gene flow between populations in New Brunswick and Nova Scotia
COLIN M. MACKINNON and ANDREW C. KENNEDY 16
- First occurrence of the Grey Fox, *Urocyon cinereoargenteus*, in New Brunswick: a climate-change mediated range expansion?
DONALD MCALPINE, JAMES D. MARTIN, and CADE LIBBY 16
- Allonursing and cooperative birthing behavior in Yellowstone Bison, *Bison bison*
JENNIFER D. JONES and JOHN J. TREANOR 17
- Weight changes in wild Wolves, *Canis lupus*, from ages 2 to 24 months
L. DAVID MECH 17
- Evidence of Raccoon, *Procyon lotor*, range extension in northern Alberta
DAVID M. LATHAM 17
- Rumen papillae morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from eastcentral Alberta
GERALD W. KUZYK and ROBERT J. HUDSON 17

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July–September 2008

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COVER: River Otter photographed 17 February 2008 at Western Arm Jeddore Harbour, Halifax County, Nova Scotia by Kim Aaboe. See Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tautoga onitis* Pages 247-252.

The Canadian Field-Naturalist

Volume 122, Number 3

July–September 2008

A Survey of Lichens and Bryophytes in White Spruce, *Picea glauca*, Tree Islands on a Calcareous Beach Ridge in Northeastern Manitoba

MICHELE D. PIERCEY-NORMORE

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Piercey-Normore, Michele D. 2008. A survey of lichens and bryophytes in White Spruce, *Picea glauca*, tree islands on a calcareous beach ridge in northeastern Manitoba. *Canadian Field-Naturalist* 122(3): 199–204.

Studies on the diversity of lichens and bryophytes in northern ecosystems have focused on open tundra and boreal forests. Krummholz tree islands have received little attention. This study examined species' diversity of lichens and bryophytes among islands of White Spruce trees in northern Manitoba. Thirty-three species were found in the tree islands with 11 additional species forming the understorey layer. The trees were dominated by epiphytic lichens and the understorey was dominated by pleurocarpous mosses. The most common lichens were widespread species. Rare lichens in the study area included *Protopannaria pezizoides* and *Alectoria nigricans* growing in the shaded interior of the tree islands. The age and density of the tree islands may produce habitat conditions different from those in mature White Spruce boreal forests. Comparative studies between White Spruce krummholz and other White Spruce stands are needed.

Key Words: *Picea glauca*, White Spruce, beach ridge, bryophytes, epiphytic lichens, krummholz, Manitoba.

Lichens and bryophytes are important components of northern ecosystems (Ritchie 1957; Longton 1988) occupying terrestrial and epiphytic niches. Epiphytic lichens play important roles in biodiversity by forming a functional relationship with spiders in spruce, *Picea* spp. forests (Gunnarsson et al. 2004) and serving as winter food for Caribou, *Rangifer tarandus* (Rominger et al. 1996). In polar regions, lichen growth is restricted by low ambient temperatures and precipitation, producing physiological drought (Lindsay 1977). Trees and shrubs in Wapusk National Park on the Hudson Bay Lowlands in northeastern Manitoba provide refuge and some protection for northern lichens. The dominant trees in these areas are *Picea glauca* (Moench) Voss, *P. mariana* (P. Mill.) BSP, and *Larix laricina* (Du Roi) K. Koch. *Picea glauca* dominates the northern treeline on the forest tundra, particularly in limestone rich areas (Ritchie 1957). Krummholz islands of *P. glauca* trees are scattered on the subarctic tundra of the Hudson Bay Lowlands in Manitoba (Scott and Hansell 2002; Piercey-Normore 2005). The Hudson Bay Lowlands is a flat coastal plain that forms a broad transition between boreal forest and arctic tundra in Manitoba and Ontario, is a band of about 160 km wide along the southwest shore of Hudson Bay (Ahti 1964; Dredge 1992). During regression of the Tyrell Sea, 8000 years ago, beach ridges were formed along the coast of Hudson Bay due to isostatic rebound, tides, and wave action. The highest

beach ridge is 122 m above sea level located near Gillam and the lowest is the present day beach along the coast of Hudson Bay. Because of the deposition of seashells and silt from the marine water during regression of the Tyrell Sea, the majority of the sand and gravel on the Hudson Bay Lowlands is calcareous (Dredge 1992).

Wapusk National Park is a large area (11 475 km²) on the southwest coast of Hudson Bay. In general, the habitat is open calcareous beach ridge crests interspersed with moist to dry *Carex* meadows running southeast to northwest parallel to the shoreline of Hudson Bay. The ridges are vegetated with *Dryas integrifolia* Vahl. and ground-dwelling lichens and bryophytes (Piercey-Normore 2005). The region has a marine subarctic climate with a mean annual temperature of -7.3°C ranging from 12°C in July to -28°C in January. Precipitation averages 400 mm annually (rainfall equivalent) (Dredge and Nixon 1992). The growing season ranges from 100 to 143 days, and prevailing winds are from the northwest. The area is underlain by continuous permafrost (Dredge and Nixon 1992). A more detailed description of the area is reported in Dredge (1992), Dredge and Nixon (1992), and Brook (2001).

Lichen studies have been done in the Northwest Territories (Bird et al. 1980, 1981), on the raised beach ridges of the Hudson Bay Lowlands in Ontario (Ahti 1964; Kershaw and Rouse 1973; Neal and Kershaw 1973), near Churchill, Manitoba (Ritchie 1957; Scott

TABLE 1. Frequency of occurrence of tree- and ground-dwelling lichen and bryophyte species in 23 spruce islands showing author's collection number in parentheses following the species epithet, and the growth habit with (L) indicating lichen and (B) indicating bryophyte. Vouchers for species marked with an asterisk are from other areas in Wapusk National Park.

Species	Frequency of occurrence (%)	Growth habit
Tree-dwelling species		
<i>Alectoria nigricans</i> (Ach.) Nyl.	8.7	Terrestrial (L)
* <i>Alectoria ochroleuca</i> (Hoffm.) A. Massal.	4.3	Terrestrial (L)
<i>Bryocaulon divergens</i> (Ach.) Kärnefelt (4779)	13.0	Terrestrial (L)
<i>Bryoria fremontii</i> (Tuck.) Brodo & D. Hawksw. (4764a)	17.4	Epiphyte (L)
<i>Bryoria lanestris</i> (Ach.) Brodo & D. Hawksw. (4769b)	4.3	Epiphyte (L)
<i>Bryoria</i> sp.	52.2	—
* <i>Caloplaca cerina</i> (Ehrh. ex Hedwig) Th. Fr.	4.3	Epiphyte (L)
<i>Caloplacacerina holocarpa</i> (Hoffm. ex Ach.) M. Wade (4767c)	4.3	Epiphyte (L)
<i>Candelariella effluorescens</i> R. C. Harris & W. R. Buck (4767d)	26.1	Epiphyte (L)
<i>Cetraria islandica</i> (L.) Ach. (4773b)	8.7	Terrestrial (L)
<i>Evernia mesomorpha</i> Nyl. (1799)	26.1	Epiphyte (L)
* <i>Flavocetraria nivalis</i> (L.) Kärnefelt & Thell	13.0	Terrestrial (L)
<i>Hypogymnia physodes</i> (L.) Nyl. (4764c)	65.2	Epiphyte (L)
<i>Lecanora circumborealis</i> Brodo & Vitik. (4772c)	8.7	Epiphyte (L)
<i>Lecanora symmetrica</i> (Ach.) Ach. (4767f)	69.6	Epiphyte (L)
<i>Lecidella euphorea</i> (Flörke) Hertel (4773c)	39.1	Epiphyte (L)
<i>Melanelia exasperatula</i> (Nyl.) Essl. (4772a)	47.8	Epiphyte (L)
* <i>Melanelia septentrionalis</i> (Lynge) Essl.	4.3	Epiphyte (L)
<i>Orthotrichum speciosum</i> Nees ex Sturm (4765a)	17.4	Epiphyte (B)
<i>Ochrolechia androgyna</i> (Hoffm.) Arnold (4765b)	43.5	Bryophilous (L)
* <i>Ochrolechia frigida</i> (Sw.) Lynge (4724)	17.4	Terrestrial (L)
<i>Parmelia sulcata</i> Taylor (4763a)	91.3	Epiphyte (L)
* <i>Parmeliopsis ambigua</i> (Wulfen) Nyl.	43.5	Epiphyte (L)
<i>Physcia adscendens</i> (Fr.) H. Olivier (4772b)	8.7	Epiphyte (L)
<i>Physcia aipolia</i> (ex Humb.) Fűrnr. (4777a)	8.7	Epiphyte (L)
<i>Physconia muscigena</i> (Ach.) Poelt (4770a)	4.3	Bryophilous (L)
<i>Protopannaria pezizoides</i> (Weber) P. M. Jørg. & S. Ekman (4775)	4.3	Tree base (L)
<i>Ramalina farinacea</i> (L.) Ach. (4764b)	56.5	Epiphyte (L)
<i>Ramalina roesleri</i> (Hochst. ex Schaerer) Hue (4766a)	21.7	Epiphyte (L)
<i>Rinodina turfacea</i> (Wahlenb.) Körber (4765c)	8.7	Epiphyte (L)
* <i>Tuckermannopsis sepincola</i> (Ehrh.) Hale / <i>americana</i> (Sprengel) Hale	8.7	Epiphyte (L)
<i>Tuckermannopsis chlorophylla</i> (Willd.) Hale (4769a)	17.4	Epiphyte (L)
<i>Usnea lapponica</i> Vainio (4778a)	8.7	Epiphyte (L)
<i>Usnea</i> sp.	17.4	—
* <i>Vulpicida pinastri</i> (Scop.) J.-E. Mattsson & M. J. Lai	52.2	Tree base (L)
<i>Xanthoria candelaria</i> (L.) Th. Fr. (4773a)	21.7	Epiphyte (L)
<i>Xanthoria</i> sp.	47.8	—
Ground-dwelling species		
<i>Aulacomnium palustre</i> (Hedw.) Schwaegr. (4780a)	5	Terrestrial (B)
* <i>A. turgidum</i> (Wahl.) Schwaegr.	15	Terrestrial (B)
* <i>Cladonia chlorophaea</i> (Flörke ex Sommerf.) Sprengel	5	Terrestrial (L)
<i>Cladonia gracilis</i> ssp. <i>elongata</i> (Jacq.) Vainio (4776a)	5	Terrestrial (L)
* <i>Cetraria islandica</i> (L.) Ach. (4734)	10	Terrestrial (L)
* <i>Dicranum elongatum</i> Schleich. ex Schwaegr.	30	Terrestrial (B)
<i>Drepanocladus uncinatus</i> (Hedw.) Warnst. (4767a)	45	Terrestrial (B)
* <i>Pleurozium schreberi</i> (Willd. ex Brid.) Mitt.	55	Terrestrial (B)
* <i>Thuidium</i> sp.	15	Terrestrial (B)
<i>Tomentypnum nitens</i> (Hedw.) Loeske (4776b)	40	Terrestrial (B)
<i>Tortula ruralis</i> (Hedw.) Gaertn., Meyer & Scherb. (4767b)	15	Terrestrial (B)

1996), and the northeastern coastal regions of Wapusk National Park in Manitoba (Piercey-Normore 2005) with no survey of the White Spruce islands (krummholz) forming characteristic clusters of trees on the beach ridges. Corticolous lichen studies have focused

on trees in boreal or temperate regions (Kuusinen 1996, and references therein) with krummholz receiving little attention (Glew 1997). No extensive lichen study has examined the White Spruce islands on the subarctic tundra in the Hudson Bay Lowlands. This study is

part of a larger study on the lichens and bryophytes of the Hudson Bay Lowlands in Manitoba. The objectives of this study were to examine lichen and bryophyte diversity and community similarity in these White Spruce islands.

Methods

Sampling and identification

The study site was a single beach ridge centered at latitude 58°28'08"N, and longitude 93°12'35.3"W, approximately 7 km inland from Hudson Bay in Wapusk National Park. This study was a brief survey of a specialized habitat, krummholz tree islands, as part of a larger survey in the national park. Twenty-three *Picea glauca* tree islands were arbitrarily chosen on a single beach ridge. Although only 20 minutes were devoted to the survey of each tree island, all available substrates were carefully checked for rare, less conspicuous lichens and bryophytes, and so the species list in Table 1 is reasonably complete. Small *Salix* shrubs were also examined when present. Species were recorded as present or absent in each island. Vouchers were collected when species identification was uncertain. However, they were not obtained for fertile *Tuckermannopsis* specimens in the islands but are available for both *T. sepincola* and *T. americana* in other park locations. Identifications of *Bryoria*, *Usnea*, and *Xanthoria* are listed in Table 1, but poorly developed specimens were not distinguished from all tree islands during the field work and are listed as *Bryoria* sp., *Usnea* sp., and *Xanthoria* sp. Vouchers are deposited in the University of Manitoba Herbarium (WIN) and collection numbers, when available, are indicated in Table 1. Twigs, tree trunk, and the ground layer were examined from exterior to interior of the island.

Lichen nomenclature follows Esslinger (1997). Bryophyte nomenclature follows the North American list provided by the Missouri Botanical Garden (<http://mobot.mobot.org/W3T/Search/most.html>). Identification keys consulted include Crum and Anderson (1981), Thomson (1984, 1997, 2003), Purvis et al. (1992), and Brodo et al. (2001). Selected species were confirmed by I. M. Brodo. Chemical compounds were detected by thin-layer chromatography (Culberson 1972, 1974).

Data analysis

The statistical package, SPSS (SPSS Inc., Chicago, Illinois), was used to test for correlations in the data. The index of similarity used was Jaccard (as described by Mueller-Dombois and Ellenberg 1974: pages 212–213). The calculation used to determine species similarity between spruce islands was the [number of species shared between island a and b / total number of species present in islands a and b] × 100.

Results

Thirty-three species of lichen-forming fungi and one species of bryophyte were found growing on the

twigs or bark of White Spruce on the exposed beach ridges in Wapusk National Park (Table 1). Five of the 33 species were terrestrial species that were carried by wind or animals and deposited onto the tree islands, two species were found at tree bases, two species were bryophilous, and one species (*Caloplaca holocarpa*) was found on *Salix* sp. growing within the White Spruce islands. All observed species have a circum-polar distribution except *Tuckermannopsis americana*, which is widely distributed in temperate regions. The most common species (>50% occurrence in 23 islands) consisted of *Hypogymnia physodes*, *Lecanora symmicta*, *Parmelia sulcata*, *Ramalina farinacea*, and *Vulpicida pinastri*. Most of the rare species (<8.7% occurrence in 23 islands) showed low abundance because of traits such as occupation of a terrestrial habitat (*Alectoria nigricans*, *A. ochroleuca*, *Cetraria islandica*), or a small thallus size (*Caloplaca cerina*, *C. holocarpa*, *Lecanora circumborealis*, *Physcia aioplia*, *P. adscendens*, *Rinodina turfacea*). Further, *Melanelia septentrionalis*, *Rinodina turfacea*, and *Tuckermannopsis sepincola/americana* were inconspicuous. Terrestrial occupation, small thallus size, or inconspicuous thalli may have resulted in some species being under-represented during the time limited survey. Presence of other poorly developed species were incorporated under the genus name, *Bryoria*, *Usnea*, and *Xanthoria*. Two rare species encountered in this habitat, *Alectoria nigricans* and *Protopannaria pezizoides*, contained well-developed thalli. *Protopannaria pezizoides* was the only cyanobacterial lichen present in the spruce islands. Unusual specimens of *Bryoria fremontii* have heavy, twisted main stems and slender secondary branches with no chemical substances, characteristic of the species. However, the same specimen also has characteristics of *B. friabilis* such as long twisted, well-developed pseudocypheae, and a brittle thallus but gyrophoric acid was absent. Eleven ground-dwelling species of lichens and bryophytes occurred in the understorey in addition to needles, sand, animal remains and other forms of detritus. The ground layer was dominated by pleurocarpous mosses and only three species of lichen-forming fungi (*Alectoria ochroleuca*, *Cetraria islandica*, and *Flavocetraria nivalis*).

The 23 tree islands ranged in size from approximately 3–5 m wide, 0.5–4 m high, with 0–60 shoots extending from the top of the green tree mass (Figure 1). Although tree islands vary in size and shape, the island in Figure 1 is higher on the right side perhaps because of protection by snow-drift from prevailing winds. These prevailing winds may kill the needles on the windward side of the shoots above the larger tree mass, leaving those on the right sides of the shoot to survive. Abrasion of snow and ice along a narrow zone above the snow deposit on the tree mass may damage or prevent growth of needles in this zone. However, less abrasion just above this zone may allow growth to occur near the tips of the shoots.

The number of lichen and bryophyte species on each of the tree islands ranged from three to 15 with an average of 9.2 species per island. Wolves appeared to be associated with the more diverse (>6 species) tree islands but the correlation was not significant ($r = -0.293$, $p = 0.237$). Based on the similarity index for pairwise comparison of tree islands, the most similar islands (>50% similarity) shared 16 of the most common species. The most dissimilar tree islands (<10% similarity) shared only five of the most common species. Because the most similar (63% similarity) and the most dissimilar (4.5% similarity) islands are also among the more species diverse, the results cannot be due to sampling artifact. The dissimilar islands appear to be dissimilar because of the combination of species rather than the presence of rare species.

Discussion

The 33 species of lichen-forming fungi found in the spruce islands represent 25% of the lichen flora reported for Wapusk National Park (Piercey-Normore 2005). Nine of these species were present on other conifers in southwestern Alberta (Kalgutkar and Bird 1969), and seven of the species and three genera were also reported to be common at the forest edge in a boreal *Picea abies* (L.) Karst. forest in Norway (Hilmo and Holien 2002). Despite the relatively poor lichen flora in this study, the total number of lichens on *P. glauca* was only slightly lower than that reported for a boreal zone (31–36 species on *Picea abies*, Kuusinen 1996; 38 species on *Picea* sp., Hyvärinen et al. 1992; 38 species on *P. abies*, Hilmo 1994). The most common species in this study (>50% occurrence in 23 islands), *Parmelia sulcata*, *Lecanora symmicta*, *Hypohymnia physodes*, *Ramalina farinacea*, and *Valpicida pinastri* are widespread boreal species and, with the exception of *R. farinacea*, are among the first to invade boreal sites. *Ramalina farinacea* is distributed along the east and west coasts of North America with sporadic reports from Alberta, Manitoba, and the Great Lakes. The reduced thallus size of this species may account for its absence in previous collections and hence its designation as “rare” in Piercey-Normore (2005).

The morphology of *Alectoria nigricans* is unusual in this habitat. It has a well-developed, pale gray, tufted, dichotomously branched thallus with many short side branches resembling *Bryoria nadvornikiana*. Pseudocyphellae are common and numerous swollen areas on the branches resemble soralia with a split cortex containing small amounts of soredia-like structures on only a few branches. The specimen of *A. nigricans* contains large amounts of alectorealic acid with trace amounts of two unknown compounds and was collected from highly diverse tree islands in this study. Another rare species, *Protopannaria pezizoides*, was also found in a highly diverse tree island. The size of the spruce islands in this study was similar to those reported by Scott and Hansell (2002) near Churchill,

Manitoba. Since climatic conditions near Churchill are similar to those in Wapusk National Park (Dredge 1992), the age of the tree islands are likely a similar 100 to 500 years old (Scott and Hansell 2002). High lichen diversity in some tree islands suggests that a larger size and older age of the tree island may provide diverse habitats, probably at later stages of succession (Topham 1977; Hilmo 1994).

Despite the declaration that density of the spruce islands may be too low to moderate the severity of the environment (Scott et al. 1993), some species such as *Alectoria nigricans*, *Candellariella effluorescens*, and *Protopannaria pezizoides* were found in specific microhabitats within the island of spruce trees. *Alectoria nigricans* was found on a twig in the shaded interior parts of a spruce island. *Candellariella effluorescens* was found on twigs on the south side of islands where more intense solar radiation and less wind resulted in generally less intense environmental impact. *Protopannaria pezizoides*, the only cyanobacterial lichen in the study, was found on soil at the base of a tree trunk in the shaded interior of an island. The specimen was very well developed and larger than other samples collected in Wapusk National Park (Piercey-Normore 2005), suggesting that this was a favourable habitat for the species. In part, the shaded interior of the island likely provided higher humidity from late snow melt and lower light levels required by cyanobacterial lichens. These lichens may have been dispersed among tree island by high winds and a relatively frictionless snow surface (Thomson 1972) or by animals such as Wolves (*Canis lupus*). The number and diversity of animal remains found within the spruce islands suggested that animals were frequently present.

The moss *Orthotrichum speciosum* has been reported from Churchill (Scott 1996) but not from Wapusk National Park and was moderately common on branches in the spruce islands (Table 1). This species is widely distributed on bark of hardwood and coniferous species and was found on some of the more sheltered branches in the tree islands. The moss sometimes formed the substrate for bryophilous species such as *Physconia muscigena* and *Ochrolechia frigida*. Although *O. frigida* is usually a terrestrial lichen (Table 1) growing over bryophytes on the ground, its unusual presence on an epiphytic moss in this study may be explained by it having been wind blown into the spruce island and becoming established on the moss. This species is easily recognized in the field by the presence of elongate fruticose outgrowths at the thallus margins.

Unlike the spruce, which was dominated by epiphytic lichen species, the understory in the islands was dominated by mosses (Table 1). The most common mosses observed were *Pleurozium schreberi*, followed by *Drepanocladus uncinatus*, *Tomentypnum nitens*, and *Dicranum elongatum*. This is similar to Scott and



FIGURE 1. Photograph of a White Spruce tree island in Wapusk National Park showing nature of the habitat, density of branches, and shoot growth above the green tree mass located on an open beach ridge.

Hansell (2002); Piercey-Normore (2005) where *Pleurozium schreberi* (Brid.) Mitt. was reported to be commonly associated with spruce islands.

In conclusion, the finding of boreal species such as *Alectoria nigricans* and *Protopannaria pezizoides* in coastal habitats suggests that these small spruce islands may also support other rare species and they deserve special attention. White Spruce krummholz islands contribute to the maintenance and diversity of epiphytes and may serve as a refugium for rare and important species not only in Wapusk National Park but also in other coastal regions of Hudson Bay. The age and density of these low arctic krummholz tree islands produce habitat conditions different from those in mature White Spruce boreal forests. There is a need for comparative studies of lichen and bryophyte niches within Manitoba's boreal forest and the White Spruce krummholz islands of the coastal region of Wapusk National Park.

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Late-Winter Habitat Use by Mule Deer, *Odocoileus hemionus*, in Central Interior British Columbia

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In central interior British Columbia, extensive cut blocks to recover timber killed by the Mountain Pine Beetle (*Dendroctonus ponderosae*) could impact negatively on Mule Deer (*Odocoileus hemionus*) late-winter habitat. This study assessed the possibility of predicting the distribution of potential late-winter habitat for Mule Deer with the BC Vegetation Resources Inventory (VRI) dataset used to produce forestry maps. On the basis of literature review and roadside inventories in December 2004, I predicted that high-quality Mule Deer late-winter habitat would correspond to mature and old conifer-dominated stands with $\leq 20\%$ deciduous species, a canopy closure $\geq 45\%$, tree heights ≥ 23 m, tree diameter at breast height ≥ 24 cm, and basal area ≥ 45 m²/ha, and would be located on $< 60\%$ slopes on south, southeast, southwest or west aspects, or on flat ground. I allocated weight values to these criteria to classify map polygons into high-, medium- and low-quality polygons, and produce predictive maps of late-winter habitat use by Mule Deer. I tested my predictive habitat rating by snowtracking along 18 km of transects in February-March 2006, and 15.6 km of transects in February 2007. I recorded 31 and 12 Mule Deer tracks in 2006 and 2007, respectively, all in high-quality polygons. The observed frequency of tracks per polygon type was significantly ($P < 0.001$) different from expected. All tracks were in mature and old conifer-dominated stands including 10-60% Lodgepole Pine (*Pinus contorta*) and 10-20% Trembling Aspen (*Populus tremuloides*). This study showed that it was possible to predict the distribution of potential late-winter habitat for Mule Deer using a series of habitat criteria and the VRI dataset. The extensive harvesting of Lodgepole Pine in mixed coniferous stands will undoubtedly have a negative impact on Mule Deer late-winter habitat quality and quantity. The rating of habitat types developed in this study should be used in forest management plans to determine sites that should be protected from logging.

Key Words: Mule Deer, *Odocoileus hemionus*, Lodgepole Pine, *Pinus contorta*, Mountain Pine Beetle, *Dendroctonus ponderosae*, sub-boreal forest, winter habitat, British Columbia.

The ability of a forest stand to intercept snow and provide both thermal cover and accessible forage are the primary habitat variables influencing deer (*Odocoileus* spp.) winter habitat selection in British Columbia and the Pacific Northwest (Kirchhoff and Schoen 1987; Hanley et al. 1989*; Nyberg et al. 1990; Armleder et al. 1994). In central British Columbia, however, recent epidemics of Mountain Pine Beetle (*Dendroctonus ponderosae*) have resulted in the infestation of at least 4.2 million hectares of Lodgepole Pine (*Pinus contorta*) stands (generally > 80 years) and the use of extensive clearcut silviculture programs to recover the timber (Readshaw 2003*). One of the goals of the new Forest and Range Practices Act (FRPA) of British Columbia is to ensure that forest cover and forage will be conserved over an area necessary for winter survival of ungulate species, recognizing regional variance in the ecology of the ungulate species. The British Columbia Ministry of Environment voiced its concerns regarding timber harvesting in the southwest portion of the Prince George Forest District where extensive cut blocks could impact negatively on Mule Deer (*Odocoileus hemionus*) late-winter habitat.

Using Mule Deer studies conducted in Douglas-fir (*Pseudotsuga menziesii*) – dominated landscapes (e.g., Kirchhoff and Schoen 1987; Armleder et al. 1994; and others), Yaremko (2003*) identified Ungulate Winter Ranges (UWRs) in the Vanderhoof Forest District.

UWRs consisted of Douglas-fir – dominated forests that were > 140 years old with a 36-65% canopy closure, located on 16-47% slopes and various aspects. Likewise, in the southern portion of the Prince George Forest District, Brade and Stevenson (2003*) identified UWRs consisting of Douglas-fir – leading stands with 0-25% slopes on southeastern or western aspects. In 2004, Canadian Forest Products Ltd. and the B.C. Ministry of Water, Land, and Air Protection identified one representative UWR in each forest district to assess their use by Mule Deer. Proulx (2004*) conducted track surveys when snow depths ranged from 15 to 60 cm. He found only one track in one UWR encompassing a Douglas-fir – Lodgepole Pine forest. He recorded three more tracks outside UWRs, in late-successional Lodgepole Pine-aspen (*Populus*) stands with $\geq 45\%$ canopy closure, tree heights ≥ 20 m, tree diameter at breast height (dbh) > 22 cm, 0-42% slopes, and southeastern aspects. Proulx (2004*) pointed out that, while Yaremko (2003*) and Brade and Stevenson (2003*) largely based their UWR selection on the presence of Douglas-fir stands, the Vanderhoof and the southern portion of the Prince George Forest districts were dominated by pure or mixed Lodgepole Pine stands. Proulx (2004*) suggested that local Mule Deer populations would be more likely found in large contiguous pine or spruce (*Picea*) stands with proper canopy and browse rather than small, disconnected Dou-

glas-fir patches. He recommended that the late-winter Mule Deer distribution be investigated in these forest districts in order to identify UWRs that would effectively meet the needs of the species.

The objective of this study was to assess and predict the late-winter distribution of Mule Deer by (1) rating the potential of forest stands according to their composition and structural characteristics; and (2) verifying habitat use by Mule Deer using snowtracking.

Study Area

The study area was southwest of Prince George (53°53'N, 122°41'W), British Columbia (Figure 1), in the Sub-boreal Spruce Biogeoclimatic Zone (Meidinger et al. 1991). Hybrid White Spruce (*Picea engelmannii* × *glauca*) and Subalpine Fir (*Abies lasiocarpa*) were the dominant climax tree species. Lodgepole Pine was common in mature forests in the drier parts of the zone, and both Lodgepole Pine and Trembling Aspen (*Populus tremuloides*) pioneered the extensive successional stands (Meidinger et al. 1991). The distribution of Douglas-fir was patchy (D. Bernier, Timberline Natural Resource Group, personal communication 2004). Black Spruce (*Picea mariana*) occurred occasionally in climax upland forest (Meidinger et al. 1991).

Methods

Rating the potential of forest stands

The selection of variables to rate the potential of forest stands to meet late-winter Mule Deer habitat requirements was first based on a literature review. It considered two important concepts used in Mule Deer winter habitat management: (1) a mixture of plant communities provides better habitat than any single community (Wallmo 1978; Mackie et al. 1982); and (2) cover and forage must be properly interspersed in order to meet Mule Deer habitat needs (Kerr 1979*; Hall 1985*). On the basis of Wood et al.'s (1999*) mule deer habitat suitability index model in pine, spruce and fir ecosystems, the following variables were identified to rate the potential of forest stands: (1) stand composition; (2) age; (3) canopy closure; (4) tree height; (5) tree diameter at breast height; (6) basal area; (7) percentage of shrub cover; (8) aspect; and (9) slope. Distance from food-rich, early-successional stands to cover was not selected as a variable because in the southwest portion of the Prince George Forest District, early- and late-successional forests are closely interspersed.

In order to quantify the selected variables, I conducted road inventories in the southern portion of the Prince George Forest District with a 4×4 truck after a heavy snowfall in December 2004. Road inventories were based on presence/not detected survey standards developed by the Resource Information Standards Committee (RIC 1998*). Transects were conducted on primary and secondary forestry roads that crossed a

diversity of habitat types characteristic of the study area (Figure 1). Only fresh tracks (i.e., ≤ 48 h old) were recorded. Both Mule Deer and White-tailed Deer (*Odocoileus virginianus*) inhabit the southwest portion of the Prince George Forest District, and their tracks cannot be distinguished accurately in the field (Murie 1975). However, Mule Deer are widespread in the region while White-tailed Deer are relatively scarce (Shackleton 1999; Proulx 2004*, personal observations). For this reason, I considered that deer tracks encountered in the study area were those of Mule Deer. As it was not possible to consistently determine if crossings were made by the same individual, all crossings were tallied (Raphael and Henry 1990*). Deer track locations were determined with a GPS unit (Garmin GPSMAP 76S, Olathe, Kansas, USA). Snow depths (average of three measurements taken 1 m apart) along roadsides and in adjacent forest stands were also recorded (Proulx and Kariz 2001*). Track locations were fed into the B.C. Vegetation Resources Inventory (VRI) dataset (B.C. Ministry of Sustainable Resource Management 2003*) in order to properly describe site characteristics. VRI is the provincial standard for assessing the quantity and quality of British Columbia's timber and other vegetation resources. It uses both photo interpretation and detailed ground sampling to arrive at an accurate assessment of timber volume and other vegetation resources within a pre-defined unit. The VRI program is a significant replacement for old "Forest Cover" mapping, as it is a broader "vegetation" inventory, designed to support a range of applications. Although snow accumulations are less important at this time of year than in February, the December survey allowed me to quantify the variables that I selected to rate the potential of forest stands and, along with data from the literature review, to predict the late-winter distribution of Mule Deer in the southern portion of Prince George Forest District.

I subjectively allocated weight values to selected variables on the basis of my evaluation of their importance in the selection of sites by Mule Deer. The sum of weights led to the classification of vector map polygons (i.e., homogeneous areas with similar forest stand characteristics) into various categories of potential winter habitat: (1) high-quality, 15-19 points; (2) medium-quality, 10-14 points; (3) low-quality, ≤ 9 points; and (4) none, 0 points. Observations gathered before and during track surveys revealed that high-quality polygons corresponded to mature (≥ 80 years old) and old, coniferous and coniferous-deciduous stands. Medium-quality polygons represented mature or old coniferous stands with poor ratings for the criteria identified in Table 1, mature coniferous-deciduous stands richer in deciduous than in coniferous species, or young (40-80 years old) coniferous forests. Low-quality polygons were immature and pole stands (1-40 years old).

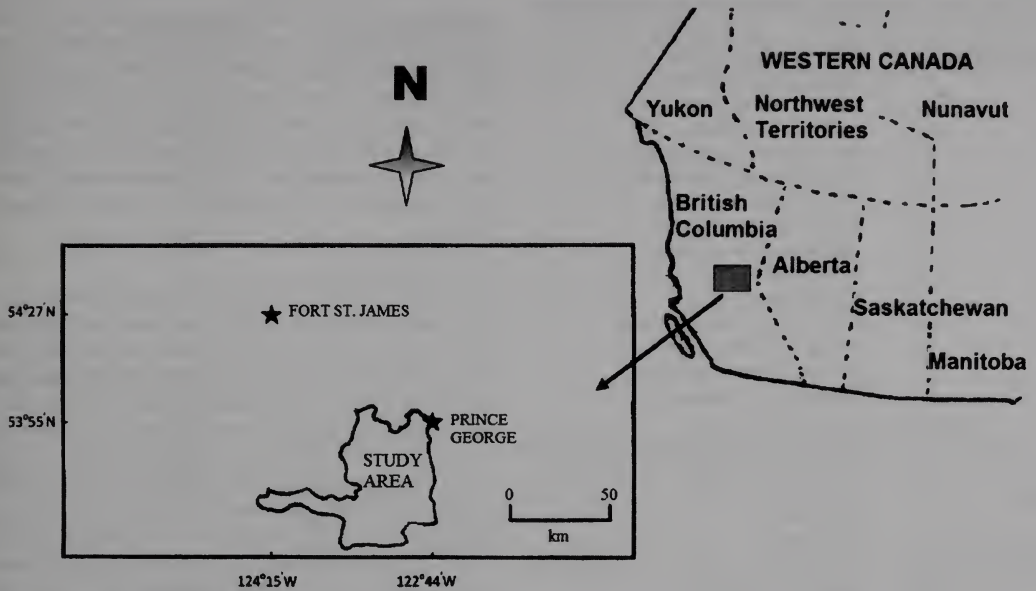


FIGURE 1. Location of study area in the southern portion of the Prince George Forest District, British Columbia.

Field assessment of potential Mule Deer habitats

Habitat use by Mule Deer was assessed in the field using snowtracking: 23 transects from 2 February to 4 March 2006, and 30 transects in February 2007. I used a stratified random sampling approach to select sample locations (Krebs 1999). Transects (≥ 500 m long and ≥ 500 m apart) were plotted on forestry maps, and starting points were tied by compass bearings and distance to distinctive topographic features. They were laid out perpendicular to the boundaries of the inventoried areas in order to include ecotones used by Mule Deer. Transects were snowshoed using a compass and 1:20 000 forestry maps.

Forest stands along survey transects were described, and classified as immature-pole (7.5–12.4 cm dbh with little understorey), young (achievement of dominance by some trees and death of others, uneven dbh, multi-storied canopy), mature (even canopy of trees, developed understorey as the canopy opens up), and old (structurally complex, established shade-tolerant species, mortality of tall and large canopy trees, canopy gaps, large down woody material) (Proulx and Kariz 2005).

Only fresh tracks (i.e., ≤ 48 h old) crossing transects were recorded. At deer track intersects, presence of crust, and snow depths in the habitat (average of three measurements taken 1 m apart) and within deer

tracks (average of measurements taken in three consecutive tracks), were recorded (Telfer 1970; Proulx and Kariz 2001*). Approximate locations along transects were determined using hip chain distances and forestry maps. In 2006, track locations were fed in VRI database in order to identify site attributes. The VRI information was compared to field observations to ensure that the classification of polygons was appropriate. In 2007, VRI data were not available for the sites inhabited by Mule Deer. Only field observations were used for stand composition, aspect and slope.

Data analyses

The proportion of inventory transects within each polygon type or habitat type was used to determine the expected frequency of tracks per polygon or habitat type. The Fisher Exact Probability Test (Zar 1999) was used to compare observed to expected frequencies of track intersects per polygon or habitat type (Proulx et al. 2006; Proulx and O'Doherty 2006). Student *t*-test was used to compare mean snow depths in stands and in Mule Deer tracks. Probability values ≤ 0.05 were considered statistically significant.

Results

Road inventories

Mule Deer tracks were encountered at five locations during road inventories. Snow depths ranged from

TABLE 1. Rating of habitat types to predict Mule Deer late-winter distribution maps in the Sub-boreal Spruce Biogeoclimatic Zone, southwest of Prince George, British Columbia.

Variables	Criteria	Weights
Stand composition	Coniferous-deciduous stands with ≥ 80 -95% conifers (all species) and 5-20% deciduous (birch, aspen, cottonwood)	6
	Coniferous-deciduous stands with ≥ 60 -<80% conifers (all species) and 21-40% deciduous (birch, aspen, cottonwood)	4
	Coniferous ($\geq 95\%$)	2
	Coniferous-deciduous stands with ≥ 20 -<60% conifers (all species) and 41-79% deciduous (birch, aspen, cottonwood)	1
Age	Deciduous (birch, aspen, cottonwood) (>80%)	Rejected polygon
	≥ 140 years	2
	≥ 80 years	1
Canopy closure	<80 years	0
	≥ 45 -<80%	3
	10-<45%, >80%	1
Tree height	0-9%	0
	≥ 23 m	1
	<23 m	0
Tree dbh	≥ 24 cm	1
	<24 m	0
Basal area	≥ 45 m ² /ha	2
	≥ 20 -<45 m ² /ha	1
	<20m ² /ha	0
% shrub cover	$\geq 10\%$	1
	<10%	0
Aspect	S, SE, SW, W, flat	2
	N, NE, E, NW	1
Slope	<60%	1
	$\geq 60\%$	0
Potential		Range of weights
High		15-19
Medium		10-14
Low		1-9
None		Rejected polygons

21 to 25 cm along roadsides, and 13-16 cm in coniferous-deciduous stands. All tracks were in late-successional (≥ 93 years old) conifer stands dominated by Lodgepole Pine or Hybrid White Spruce, with $\leq 30\%$ Trembling Aspen. All the stands had $> 50\%$ canopy closure, tree height > 24 m, tree dbh > 24 cm, basal area ≥ 45 m²/ha, and were located on 5-20% slopes on west or south-southwest aspects.

Habitat rating

Proulx's (2004*) findings and the December roadside inventories suggested that conifer-dominated

stands with presence of Trembling Aspen would have greater potential for Mule Deer in late winter (Table 1). I assumed that stands with $> 95\%$ conifers or $> 80\%$ deciduous would be less valuable, the former offering valuable thermal cover but short-term forage, and the latter, abundant food but poor snow-intercepting cover (Table 1). Stands with greater potential for Mule Deer would have a canopy closure $\geq 45\%$, tree heights ≥ 23 m, tree dbh ≥ 24 cm, and a basal area ≥ 45 m²/ha, and would be located on $< 60\%$ slopes on south, south-east, southwest or west aspects or on flat ground (Table 1).

Field assessments

In 2006 and 2007, temperatures ranged from -10 to 0°C, and all inventories were conducted ≤ 48 h since a snowfall or flurries. In 2006, there was an average of 41 (\pm standard deviation 12.9) cm of snow in openings, and 32 (± 4.8) cm in forested habitats. At Mule Deer track intercepts, average snow depths in stands ($n = 5$, $\bar{x} = 31.6 \pm 5.3$ cm) were significantly ($t = 3.50$, $P < 0.05$) deeper than in deer tracks ($n = 5$, $\bar{x} = 18.8 \pm 6.2$ cm). In 2007, there was an average of 44 (\pm standard deviation 16.8) cm of snow in openings, and 32 (± 16) cm in forested habitats. At Mule Deer track intercepts, average snow depths in stands ($n = 7$, $\bar{x} = 24.6 \pm 10.2$ cm) were significantly ($t = 3.40$, $P < 0.05$) deeper than in Mule Deer tracks ($n = 7$, $\bar{x} = 11.2 \pm 4.6$ cm). During both years, a thin crust was present 8-12 cm below the snow surface.

Frequency of Mule Deer Tracks per Polygon Type

Thirty-one and 12 Mule Deer tracks were recorded in 2006 (17955 m of transects) and 2007 (15631 m of transects), respectively, all in high-quality polygons. During both years, the observed frequency of tracks per polygon type (Table 2) was significantly ($P < 0.001$) different from expected.

Frequency of Mule Deer Tracks per Habitat Type

In 2006, all Mule Deer tracks were in mature and old stands (Table 2). The observed frequency of Mule Deer tracks per habitat type was significantly different from expected ($P < 0.001$). Mule Deer frequented conifer-dominated stands with 10-60% Lodgepole Pine and 10-20% Trembling Aspen (Table 2).

In 2007, all Mule Deer tracks were in mature stands (Table 2). The observed frequency of tracks per habitat type was significantly different from expected ($P = 0.01$). All tracks were recorded in Hybrid White Spruce-Lodgepole Pine – dominated stands that also included Trembling Aspen (Table 2).

Attributes of Polygons with Mule Deer Tracks

In 2006, all tracks were in mature and old conifer-dominated stands with a 50-60% canopy closure, tree height > 30 m, dbh > 26 cm, a basal area ranging from 30 to 55 m²/ha, 10-20% shrub cover, on $< 25\%$ slopes on NW and SW aspects.

In 2007, all tracks were located in mature conifer-dominated stands on $< 30\%$ slopes on W-SW aspects.

TABLE 2. Proportions of transects inventoried per polygon and habitat types, and distribution of Mule Deer tracks in late-winter 2006 and 2007, in southern Prince George Forest District.

Category	2006 Inventory		2007 Inventory	
	Transect lengths m (%)	Mule Deer tracks (%) & stand composition	Transect lengths – m (%)	Mule Deer tracks (%) & stand composition
<i>Polygon quality</i>				
High	6425 (35.8)	31 (100)	5751 (36.8)	12 (100)
Medium	6351 (35.4)	0 (0)	1876 (12)	0 (0)
Low	5179 (28.8)	0 (0)	8004 (51.2)	0 (0)
Total	17955 (100)	31 (100)	15631 (100)	12 (100)
<i>Habitat type</i>				
Immature-Pole	4903 (27.3)	0 (0)	7334 (46.9)	0 (0)
Young	1004 (5.6)	0 (0)	1068 (6.8)	0 (0)
Mature	10150 (56.3)	19 (61.3) All in 80% Fd / 10% PL / 10% At*	5379 (34.4)	12 (100) All in Sxw / Pl/ At*
Old	1898 (10.6)	12 (38.7): 7 in 70% Fd / 20% Sxw / 10% Pl* 1 in 60% Pl / 20% Sxw / 10% At* 4 in 50% Sxw / 30% Pl / 20% At*	1850 (11.8)	0 (0)
Total	17955 (100)	31 (100)	15631 (100)	12 (100)

*At: Trembling Aspen; Fd: Douglas-fir; Pl: Lodgepole Pine; Sxw: Hybrid Spruce (Engelmann × White)

Discussion

This study showed that, in the Sub-boreal Spruce Biogeoclimatic Zone southwest of Prince George, Mule Deer late-winter habitat corresponded to high-quality polygons, which included late-successional stands with a well-developed canopy that provided thermal protection and snow cover interception. This is in agreement with previous studies (Armleder et al. 1994; Poole and Mowat 2005) that found that in late winter, Mule Deer seek late-successional coniferous stands with greater crown closure. This study also showed that, in 2006, a large number of Mule Deer tracks were located in Douglas-fir-leading stands, as it was found in west-central (D’Arcy and Stark 1998*) and south-central (Armleder et al. 1994) interior regions rich in Douglas-fir stands. In this study, however, the distribution of Douglas-fir stands was patchy, and Mule Deer also used Lodgepole Pine-Hybrid White Spruce stands that provided animals with canopy cover. All these conifer-dominated stands had a small deciduous component that provided Mule Deer with food. Mule Deer selected these stands at a time of year when snow was deep enough to incite animals to seek snow-intercepting canopy cover. Indeed, deer energy expenditures increase by 50% in 25 cm of snow, and more than double in 40 cm (which represents about 60% of brisket height) (Parker et al. 1984). This study suggests that Mule Deer habitat preferences in central interior BC may change according to the availability of various coniferous stands.

Because an interspersation of forage and conifer cover may provide Mule Deer with valuable habitat year-round (Deschamp et al. 1979; Poole and Mowat 2005), timber harvesting programs should be compatible with Mule Deer habitat requirements. This study showed that the VRI dataset can be advantageously used to predict Mule Deer winter habitat use. The rating of habitat types developed in this study should be used in forest management plans to determine sites that should be protected from logging. The extensive harvesting of Mountain Pine Beetle-killed Lodgepole Pines will undoubtedly have a negative effect on Mule Deer late-winter habitat quality and quantity. In mixed coniferous stands with dead patches of Lodgepole Pine, canopy cover is still provided by Hybrid White Spruce and Douglas-fir; the loss of pine opens up the canopy and allows growth of deciduous shrubs and the production of browse. These mixed coniferous stands should be protected at the expense of pure Lodgepole Pine forests, which do not offer an interspersation of cover and food to Mule Deer. The harvest of pure Lodgepole Pine stands should be planned not to impact on the environmental conditions surrounding high-quality polygons for Mule Deer. Timber harvest up to the edge of high-quality polygons, and incursions within these polygons to remove patches of dead trees, impact considerably on forest interior conditions. Finally, because of extensive clearcuts to harvest dead Lodgepole Pine stands, landscapes located in the southern portion of the Prince George Forest District

have become highly fragmented. It is essential for the survival of Mule Deer during winters with cold temperatures and deep snow accumulations that connectivity between high-quality polygons be maintained through the establishment and protection of a corridor network encompassing late-successional, mixed coniferous stands with Trembling Aspen.

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Factors Influencing the Abundance of Berry Plants for Black Bears, *Ursus americanus*, in Quebec

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Berries generally represent the primary food source used by Black Bears (*Ursus americanus*) during summer and sometimes fall. Our study attempted to identify factors influencing the abundance of these critical resources for Black Bears in Quebec. We used data from the ecological inventories of the Ministère de l'Environnement du Québec. Three different study areas were selected, including the Papineau-Labelle Wildlife Reserve (326 sample plots; 24 species), the Laurentides Wildlife Reserve (679 sample plots; 16 species) and the Côte-Nord administrative region (1944 sample plots; 30 species). Each site represented a different bioclimatic domain. Characteristics of the dominant vegetation (density and height), soil texture, and drainage classes (vertical or oblique) were used as analysis factors. In general, height and density of the dominant vegetation had a significant effect on the abundance of berry plants. Berry plants were more abundant in plots where dominant vegetation height and density were low. Soil texture had little effect on the abundance of berry plants, and the influence of drainage varied depending on the region. This study allowed us to determine the optimal sites of berry resources for Black Bears.

Key Words: Black Bear, *Ursus americanus*, berries, oblique drainage, seepage, soil texture, vegetation density, vegetation height, vertical drainage, wildlife reserve, Quebec.

Berries generally represent the major food source for Black Bears (*Ursus americanus*) during summer (Jonkel and Cowan 1971; Hatler 1972; Lindzey and Meslow 1977; Landers et al. 1979; Young and Ruff 1982; Maehr and Brady 1984; Irwin and Hammond 1985; Rogers 1987; Unsworth et al. 1989; Holcroft and Herrero 1991; Schwartz and Franzmann 1991; Kasbohm et al. 1995; Rudis and Tansey 1995; Noyce and Garshelis 1997; Welch et al. 1997). In fall, when hard masts are unavailable, Black Bears will also continue to eat berries (Young and Ruff 1982; Holcroft and Herrero 1991; Schwartz and Franzmann 1991; Boileau et al. 1994; Kasbohm et al. 1995).

In Quebec, the Black Bear's diet has been described in three main studies (Boileau et al. 1994; Samson 1995; Leblanc 2000). Similar to findings in studies across the rest of their range, Black Bears have a tendency to eat berries according to availability. The dominant berry species found in diets often vary according to geographic location. Boileau et al. (1994) found that in the Gaspésie Park, the berry species most consumed by Black Bears were serviceberries (*Aamelanchier* spp.), Wild Sarsaparilla (*Aralia nudicaulis*), Red-osier Dogwood (*Cornus stolonifera*), American Strawberry (*Fragaria americana*), currants (*Ribes* spp.), raspberries (*Rubus* spp.), Pink Streptopus (*Streptopus roseus*), blueberries (*Vaccinium* spp.) and Low-bush Cranberries (*Viburnum edule*). In another study, conducted in La Mauricie National Park, Samson

(1995) found Black Bears sought mainly Raspberries (*Rubus idaeus*), blueberries, cherries (*Prunus* spp.) and Bristly Sarsaparilla (*Aralia hispida*). To a lesser extent, Black Bears in this region consumed fruits from Beaked Hazelnut (*Corylus cornuta*), hawthorn (*Crataegus* sp.) and viburnums (*Viburnum* spp.). Fruits of Fetid Currant (*Ribes glandulosum*), Red-berried Elder (*Sambucus pubens*) and Mountain Ash (*Sorbus americana*) were infrequently observed in scats (fecal droppings) (Samson 1995). In a third study, in Forillon National Park, Red-osier Dogwood, Mountain Ash, Wild Sarsaparilla, viburnums, cherries, serviceberries and Beaked Hazelnut were the main species consumed (Leblanc 2000). To a limited extent, strawberries (*Fragaria* spp.), raspberries, roses (*Rosa* spp.), Bunchberry (*Cornus canadensis*) and currants were also consumed (Leblanc 2000).

Noyce and Coy (1990) reported that the abundance and productivity of berry plants as a food source for Black Bears diminished with increasing canopy density. Noyce and Coy (1990) also reported that berry plants were more abundant on well-drained soils with a sandy and loamy texture. In this study, we attempt to verify whether the abundance of berry plants, in different regions of Quebec, is influenced by the same factors as reported by Noyce and Coy (1990) in Minnesota. Thus, we hypothesize that, independent of the ecological region, berry plants should be more abundant in open forests and on well-drained soils. Although

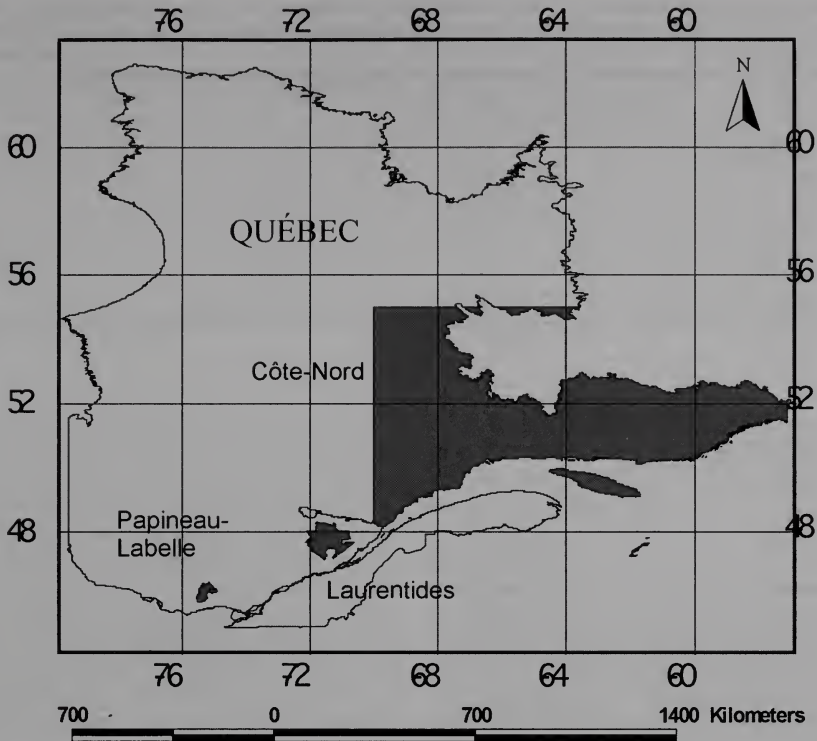


FIGURE 1. Location of the three study areas in Québec: the Papineau-Labelle Wildlife Reserve, the Laurentides Wildlife Reserve, and the Côte-Nord region.

many species of mammals and birds consume berries, we focused on berries as a resource for Black Bears.

Study Areas

We chose three different study areas located within Quebec (Figure 1), each representing a different bioclimatic domain. Our first study area was the Papineau-Labelle Wildlife Reserve, located about 80 km north-east of Hull. It was created in 1971 and has a total area of 1628 km² (Société des établissements de plein air du Québec 2000a). The Papineau-Labelle Wildlife Reserve represents the Sugar Maple (*Acer saccharum*)–Yellow Birch (*Betula alleghaniensis*) domain (Bérard and Côté 1996). The reserve receives 158 days of precipitation annually, falling as 819 mm of rain and 241 cm of snow (Chénéville station) (Environnement Canada 1993). Mean annual temperature is 3.8°C, with a mean temperature of -12.9°C in January and 18.3°C in July (Environnement Canada 1993).

Our second study area was the Laurentides Wildlife Reserve, located between Chicoutimi and Québec City. The Laurentides Wildlife Reserve was created in 1895 and has a surface area of 7961 km² (Société des établissements de plein air du Québec 2000b). It represents the Balsam Fir (*Abies balsamea*)–Paper Birch (*Betula*

papyrifera) domain (Bérard and Côté 1996). The study area has 215 days a year with measurable precipitation, receiving 948 mm of rain and 593 cm of snow (Forêt Montmorency station) (Environnement Canada 1993). Mean annual temperature is 0.3°C, with a mean temperature of -15.3°C in January and 14.8°C in July (Environnement Canada 1993).

Our third study area was the Côte-Nord region. With an area of 328 693 km², it is the second largest administrative region in Quebec (Cartier 1990). The territory includes Anticosti Island and stretches for 1300 km along the coast between Tadoussac and Blanc-Sablon (Cartier 1990). The Côte-Nord region represents the Black Spruce (*Picea mariana*)-lichen domain (Bérard and Côté 1996). The study area has 179 days a year with measurable precipitation, receiving 782 mm of rain and 333 cm of snow (Natashquan A station) (Environnement Canada 1993). Mean annual temperature is 1.1°C, with a mean temperature of -12.9°C in January and 14.2°C in July (Environnement Canada 1993).

Methods

We used vegetation data collected by the Ministère de l'Environnement du Québec, from the ecological inventories program. Methodology is described by the

TABLE 1. List of berry species considered for Black Bears in our three study areas. The *n* indicates the total number of plots. For each species, the frequency (number of plots) and the corresponding proportion of plots (%) containing the species are shown.

Species	Papineau-Labelle Wildlife Reserve <i>n</i> = 326	Laurentides Wildlife Reserve <i>n</i> = 679	Côte-Nord region <i>n</i> = 1944
<i>Anelanchier bartramiana</i>	—	—	136 (7.0%)
<i>Anelanchier</i> sp.	4 (1.2%)	—	—
<i>Aralia nudicaulis</i>	89 (27.3%)	7 (1.0%)	45 (2.3%)
<i>Aralia racemosa</i>	4 (1.2%)	—	—
<i>Arctostaphylos alpina</i>	—	—	43 (2.2%)
<i>Arctostaphylos uva-ursi</i>	—	—	8 (0.4%)
<i>Cornus alternifolia</i>	6 (1.8%)	—	—
<i>Cornus canadensis</i>	14 (4.3%)	272 (40.1%)	773 (39.8%)
<i>Cornus stolonifera</i>	6 (1.8%)	—	25 (1.3%)
<i>Cornus suecica</i>	—	—	1 (0.1%)
<i>Corylus cornuta</i>	91 (27.9%)	—	—
<i>Crataegus</i> sp.	1 (0.3%)	—	—
<i>Empetrum atropurpureum</i>	—	—	2 (0.1%)
<i>Empetrum eamesii</i>	—	—	3 (0.2%)
<i>Empetrum nigrum</i>	—	—	356 (18.3%)
<i>Fragaria virginiana</i>	—	—	2 (0.1%)
<i>Prunus pensylvanica</i>	21 (6.4%)	1 (0.1%)	6 (0.3%)
<i>Prunus serotina</i>	49 (15.0%)	—	—
<i>Prunus virginiana</i>	9 (2.8%)	—	—
<i>Ribes americanum</i>	1 (0.3%)	1 (0.1%)	—
<i>Ribes glandulosum</i>	1 (0.3%)	83 (12.2%)	57 (2.9%)
<i>Ribes lacustre</i>	—	3 (0.4%)	22 (1.1%)
<i>Ribes triste</i>	—	5 (0.7%)	1 (0.1%)
<i>Ribes</i> sp.	2 (0.6%)	—	—
<i>Rubus acaulis</i>	—	—	4 (0.2%)
<i>Rubus allegheniensis</i>	3 (0.9%)	—	—
<i>Rubus chamaemorus</i>	—	102 (15.0%)	252 (13.0%)
<i>Rubus idaeus</i>	27 (8.3%)	73 (10.8%)	20 (1.0%)
<i>Rubus odoratus</i>	4 (1.2%)	—	—
<i>Rubus pubescens</i>	34 (10.4%)	5 (0.7%)	36 (1.9%)
<i>Sambucus pubens</i>	23 (7.1%)	37 (5.4%)	5 (0.3%)
<i>Sorbus americana</i>	—	7 (1.0%)	—
<i>Sorbus decora</i>	—	5 (0.7%)	73 (3.8%)
<i>Vaccinium angustifolium</i>	1 (0.3%)	60 (8.8%)	894 (46.0%)
<i>Vaccinium cespitosum</i>	—	—	283 (14.6%)
<i>Vaccinium myrtilloides</i>	3 (0.9%)	1 (0.1%)	19 (1.0%)
<i>Vaccinium ovalifolium</i>	—	—	32 (1.6%)
<i>Vaccinium oxycoccos</i>	—	—	27 (1.4%)
<i>Vaccinium uliginosum</i>	—	—	290 (14.9%)
<i>Vaccinium vitis-idaea</i>	—	—	288 (14.8%)
<i>Viburnum cassinoides</i>	8 (2.5%)	—	10 (0.5%)
<i>Viburnum edule</i>	—	5 (0.7%)	78 (4.0%)
<i>Viburnum lentago</i>	1 (0.3%)	—	—
<i>Viburnum rafinesquianum</i>	1 (0.3%)	—	—

Service des inventaires écologiques (1981). In each sample plot, vegetation was identified to species (Table 1). Only berry species sought by Bears were selected. Each species was quantified with a Braun-Blanquet (1932) abundance-dominance index (1 = <5% (median = 2.5%); 2 = 5-25% (median = 15%); 3 = 26-50% (median = 38%); 4 = 51-75% (median = 63%); 5 = ≥76% (median = 88%)). In order to determine the abundance of food for Black Bears in each sample plot, we totaled the median value of all species potentially part of the Black Bear's diet. To keep the same number of classes the initial data had, we converted the total

percentage cover of berry plants to an abundance index with equal classes (1 = 1-20%; 2 = 21-40%; 3 = 41-60%; 4 = 61-80%; 5 = 81-100%).

The environment of each sample plot was described using the following variables: density and height of the dominant vegetation, soil texture, vertical drainage and oblique drainage (seepage). To determine the relationship between these environmental variables and the total abundance of berry plants, we first used a model averaging approach, based on Akaike's Information Criterion (AIC). The lowest delta AIC value indicates the best model (Burnham and Anderson 2002; Maze-

TABLE 2. Results of the model selection analysis to determine which environmental variables explain best the total abundance of berry plants in three regions of Québec. The lowest delta AIC value indicates the best model.

Models	Papineau-Labelle Wildlife Reserve		Laurentides Wildlife Reserve		Côte-Nord region	
	Rank	Delta AIC	Rank	Delta AIC	Rank	Delta AIC
Density	6	13.0	8	42.6	3	127.1
Height	3	6.8	2	4.6	6	183.5
Density and height	2	5.8	3	5.1	2	10.8
Soil texture	7	14.3	6	41.8	8	235.1
Vertical drainage	8	14.5	4	33.6	7	205.9
Oblique drainage	4	8.2	7	41.9	5	167.3
All drainage	5	10.9	5	35.3	4	156.3
All variables	1	0.0	1	0.0	1	0.0

rolle 2006). We then compared the influence of each variable using *t* tests for simple comparisons or Bonferroni *t* tests for multiple comparisons. We considered results of statistical tests to be significant at $P < 0.05$.

A total of 326 plots were sampled in the Papineau-Labelle Wildlife Reserve, containing a total of 24 berry species potentially important for Black Bears. In the Laurentides Wildlife Reserve, there were 679 plots containing a total of 16 berry species. Finally, a total of 1944 plots were sampled in the Côte-Nord region, containing a total of 30 berry species of interest to Black Bears. No sample plots were located on Anticosti Island.

Results

Forty-four species of berry plants sought by Black Bears were found in the regions under study (Table 1). We examined the influence of the selected environmental variables on the total abundance of these berry plants in each study area. The model selection analysis indicated that the general model that included all the variables is the best model that explains the total abundance of berry plants for Black Bears (Table 2). However, density and height of the dominant vegetation were the most important variables in the models. The effect of density was significant only in the Côte-Nord region, but the tendencies in all study areas indicated that berry plants were mostly found in stands where the density of the dominant vegetation was low (Figure 2). The results were clearer with the height of the dominant vegetation, where berry plants were significantly more abundant in open stands (height of the dominant vegetation < 3 m) in all three study areas (Figure 3).

Soil texture and drainage (vertical and oblique) always ranked among the weakest variables. Berry plants had a tendency to be more abundant in sand-loam soils, but there was a greater variability in silt-clay soils (Figure 4). Influence of vertical and oblique drainage varied depending on the region. In the Laurentides Wildlife Reserve, berry plants were more abundant in plots with humid vertical drainage (Figure 5). In the Papineau-Labelle Wildlife Reserve and in the

Côte-Nord region, berry plants were more abundant in plots with dry vertical drainage (Figure 5). Oblique drainage had a significant influence only in the Côte-Nord region (Figure 6).

Discussion

Influence of dominant vegetation height and density on the abundance of berry plants

Observed tendencies concerning the effect of dominant vegetation height and density on the abundance of berry plants agree with the existing literature. Noyce and Coy (1990) reached the same conclusion as our study, finding berry plants to be more abundant in open areas. Noyce and Coy (1990) also reported that berry productivity was the highest in open areas, so it might also be the case in our study. Hellgren et al. (1991) found that clearcuts and burned sites are good producers of berries. Boileau et al. (1994) affirmed that clearcuts had more berry plants in the Gaspésie Park. In another study, Irwin and Hammond (1985) noted that clearcuts, located in high altitude in Wyoming, contained several berry species consumed by Black Bears. Selective cuts, where the canopy is partially removed, also provide a good variety of berries for Black Bears due to the reduction in canopy density (Young and Beecham 1986; Unsworth et al. 1989). However, berries are generally less abundant in selective and partial cuts than in clearcuts (Costello and Sage 1994). Rudis and Tansey (1995) confirmed that Black Bears were using berry species typically found in clearcuts and other disturbed areas during summer months. Finally, in Quebec's mixed forest, Hébert (2000) found that there were significantly more berry plants for Black Bears in small gaps (< 200 m²) than under the adjacent forest cover.

Furthermore, studies have found that as open areas closed, their capacity to maintain berry plants diminished. On Long Island, Washington, Lindzey et al. (1986) reported that Black Bear numbers diminished as the vegetation in clearcuts gradually regenerated itself. However, in recently disturbed areas, berries often become abundant only after a few years, which could eventually put more variability in the relation between

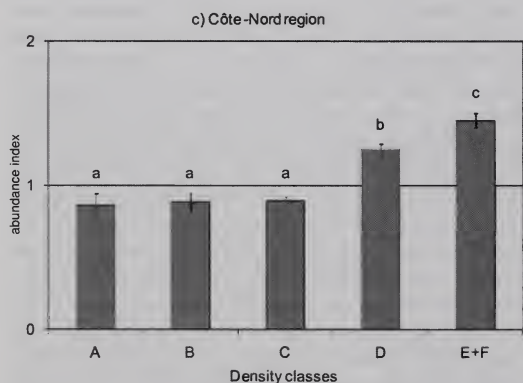
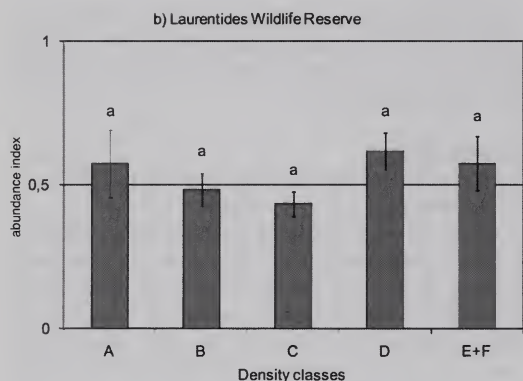
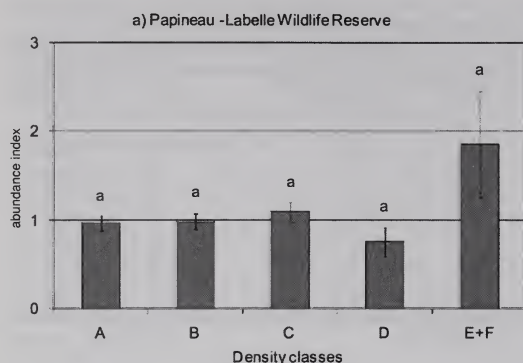


FIGURE 2. Influence of dominant vegetation density on the abundance (mean \pm standard error) of berry plants for Black Bears in three regions of Québec. Class A represents the highest density whereas class E+F represents the lowest density. Means with the same letter were not significantly different.

density and height of the dominant vegetation and the abundance of berry plants. In the State of New York, the abundance of berries peaked in 9 to 24 year-old clearcuts (Costello and Sage 1994). In Minnesota, berries were most abundant between 5 and 8 years following disturbance, but became gradually less abundant after 16 years (Noyce and Coy 1990). In the Gas-

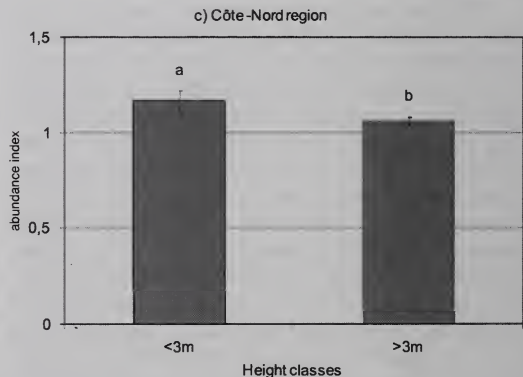
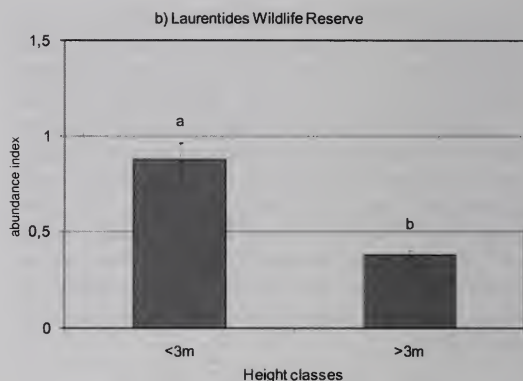
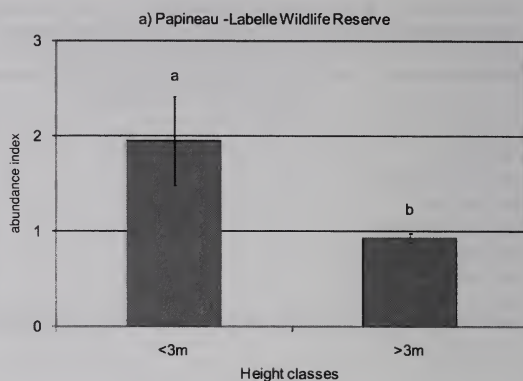


FIGURE 3. Influence of dominant vegetation height on the abundance (mean \pm standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

pésie, clearcuts younger than 15 years old had more berries than older cuts (Boileau et al. 1994).

Finally, Mabry et al. (2000), after a classification of vegetation by morphological traits, affirmed that having berries is a feature associated with high site exposure, or solar radiation potential. Thus, plants with this morphological trait are mostly found in open areas.

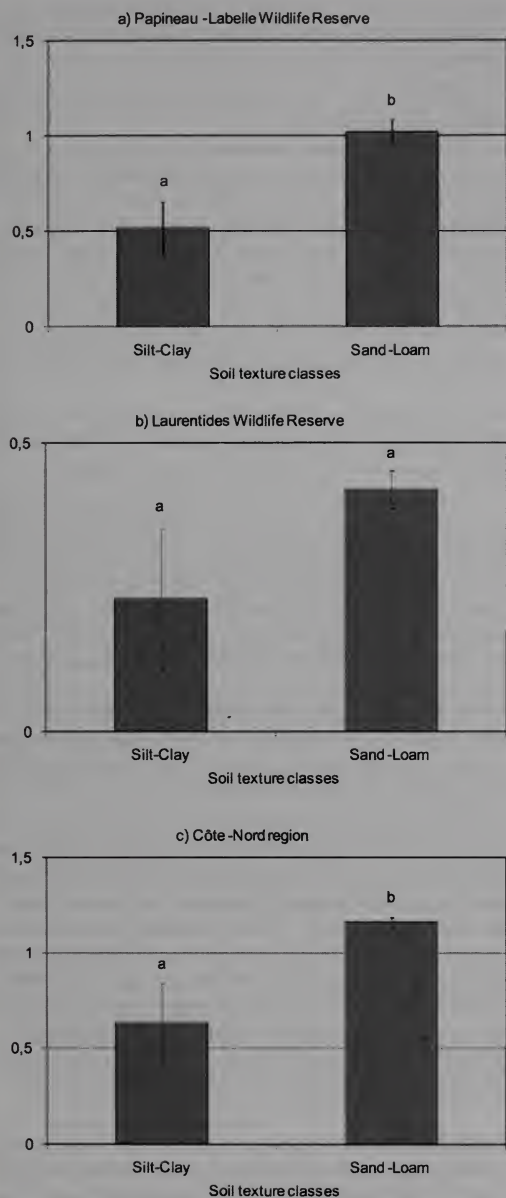


FIGURE 4. Influence of soil texture on the abundance (mean \pm standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

Influence of soil texture on the abundance of berry plants

According to our results, the influence of soil texture is weak on the abundance of berry plants for Black Bears. According to the results of Whitney (1991), the association of berry plants with soil texture (sand and gravel) was variable depending on the species. In another study done by Noyce and Coy (1990), pre-

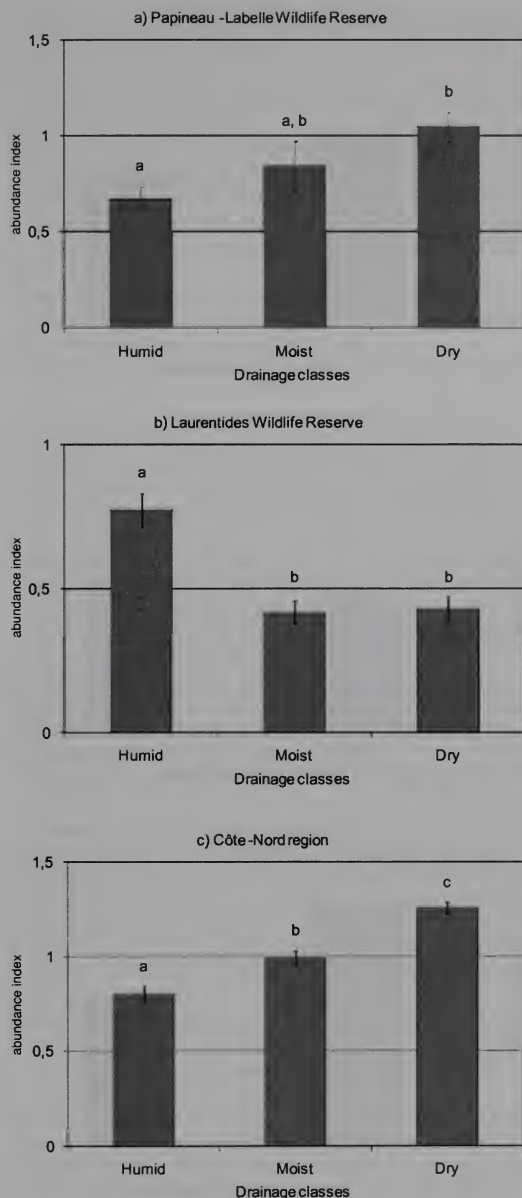


FIGURE 5. Influence of vertical drainage on the abundance (mean \pm standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

ference of soil texture was also variable among species.

The general influence of soil texture on plant vegetation is not always obvious. In Missouri, Lyon and Sagers (1998) found that soil texture only poorly explains variation in the vegetation of riparian forests. In the Haut-Saint-Laurent, in Quebec, Meilleur et al. (1992) observed no effect of soil texture on vegetation. In a steppe in the USA, more shrub species were found

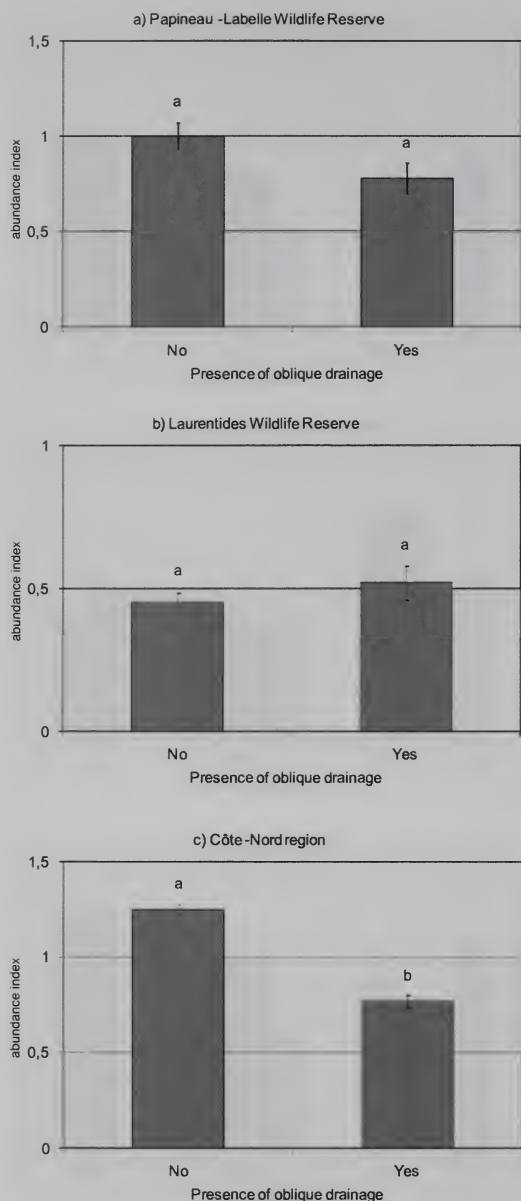


FIGURE 6. Influence of oblique drainage (seepage) on the abundance (mean \pm standard error) of berry plants for Black Bears in three regions of Québec. Means with the same letter were not significantly different.

in intermediate soil textures, whereas more herbaceous species were encountered when soil texture was finer (Dodd and Lauenroth 1997; Lane et al. 1998). However, even in these studies, soil texture did not have a significant effect on the aboveground net primary production (Lane et al. 1998).

According to Meilleur et al. (1992), soil texture is less important than general drainage conditions. How-

ever, it is well known that soil texture can affect the water retention potential (Dodd and Lauenroth 1997; Lane et al. 1998; Singh et al. 1998).

Influence of vertical and oblique drainage on the abundance of berry plants

Contrary to existing literature, the results of our study show no clear tendency in the preferences of berry plants for specific drainage patterns. Other studies have found marked effects of drainage on general vegetation composition and abundance (Laine et al. 1995; Laiho 1996; Minkinen et al. 1999). In Finland, several wetlands have been converted to dry areas for forestry. When the water level was permanently reduced, a secondary vegetal succession initiated itself, favoring a forest-type community (Laine et al. 1995; Laiho 1996; Minkinen et al. 1999). Among the forest species that established themselves, Laine et al. (1995) noted the presence of *Vaccinium* spp. among others.

Several attempts involving ecological classification of vegetation have also been done (Whitney 1991; Carter et al. 1999; Motzkin et al. 1999; Mabry et al. 2000). In those classifications, drainage is sometimes used to characterize plant communities. However, when considering only the berry species used by Black Bears in those classifications, conclusions are equally variable as those in our study (Whitney 1991; Carter et al. 1999; Motzkin et al. 1999; Mabry et al. 2000). Mabry et al. (2000) even identified some morphological traits of berry species that are linked with a dry or humid drainage. The results of Motzkin et al. (1999) were quite variable, showing that the best predictor of the presence of some berry species is sometimes drainage, sometimes the kind of land use, sometimes the soil quality, or sometimes the presence of natural disturbances. Whitney (1991) also found that the association of berry plants with types of drainage varies from one species to another. However, Noyce and Coy (1990) reported that the abundance of berry plants for Black Bears was greatest on well-drained soils, moderate on poorly-drained mineral soils, and lowest on poorly-drained organic soils.

Conclusion

As underlined by Motzkin et al. (1999), a major goal of plant ecology is to determine the factors that control species distributions and community composition. For berry species, the most important variables appear to be height and density of the stands, which are related to the amount of light reaching the plants. Soil texture appears to have a weak influence on berry plants in Quebec. As for drainage, the variability of the effects from region to region could be explained by two main factors. First, many species examined may have a wide range of tolerance to variability in drainage. Therefore, some species could survive equally well in humid as in dry drainage. Secondly, we grouped all berry species together. Some berry species may be strongly associated with a certain drainage

pattern while others do better under the opposite conditions. Hence, when grouped together, the drainage preferences mask each other and we observe no tendency. However, this study allowed us to determine the optimal sites of berry resources for Black Bears.

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Spatial Interactions of Yarded White-tailed Deer, *Odocoileus virginianus*

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We examined the spatial interactions of nine female White-tailed Deer (*Odocoileus virginianus*) in two deeryards (winter aggregations) in northeastern Minnesota during February-April 1999. Global positioning system (GPS) collars yielded seven pair-wise comparisons of deer that were located at the same time (≤ 1 minute apart) and that used overlapping areas. Deer traveled separately and did not associate with one another. Within overlapping areas, comparisons of distances between deer and distances between random locations indicated deer moved without regard to each other. Similarly, comparisons of observed and expected probabilities of deer using areas overlapping those of other deer also evinced that deer moved independently.

Key Words: White-tailed Deer, *Odocoileus virginianus*, GPS tracking, movements, space use, home-range overlap, radio-tracking, spatial interaction, Minnesota.

Every autumn, northern White-tailed Deer (*Odocoileus virginianus*) migrate from individual summer home ranges and aggregate in winter deeryards dominated by coniferous forests which have reduced snow depths compared to adjacent deciduous forests (Severinghaus and Cheatum 1956). The trail systems produced by many deer enhance access to forage and is advantageous in escape from predators (Messier and Barrette 1985; Nelson and Mech 1981). All sub-units of deer society, single deer, females with fawns, matriarchal groups, male groups, and mixed groups (Hawkins and Klimstra 1970), occupy deeryards. Except for a deer's group members and perhaps deer that overlapped with them on their summer range, yarded deer encounter unfamiliar deer originating from different summer ranges (Nelson and Mech 1987).

Initially, deeryards appear as places where large numbers of deer intermingle. However, winter home-range sizes of yarded deer are generally < 200 ha (Lesage et al. 2000), whereas deeryards can be 1-3 orders of magnitude larger (Nelson and Mech 1987; Van Deelen et al. 1998; Whitelaw et al. 1998; Lesage et al. 2000; Sabine et al. 2002). Thus, it is clear that individual deer do not move throughout their entire deeryard, but occupy smaller home ranges adjacent to or overlapping a subset of all the deer using a deeryard.

Interactions among yarded deer with overlapping home ranges have not been examined, because the dense vegetation in deeryards prohibits direct observation. At openings within deeryards where supplemental feed was provided, deer have been seen aggressively displacing other deer attempting to feed at the same site (Kabat et al. 1953; Ozoga 1972). However, it is unknown whether conflicts influenced space use when deer returned to dense cover.

Radio-tracking allows the study of deer spatial dynamics without having to observe deer directly. For pairs of deer using overlapping areas, and located simultaneously, movements, distances between locations (Doncaster 1990) and simultaneous use of overlaps quantify spatial interactions (Minta 1992; Powell et al. 1997; Powell 2000). Such results can then provide evidence of attraction, avoidance, or no interaction among deer.

Only one radio-tracking study located yarded deer simultaneously, but it employed a fixed-base automatic tracking system, and only measured home-range size and timing of migration (Rongstad and Tester 1969). The spatial interactions of the yarded deer were not examined.

The recent development of global positioning system (GPS) radio-telemetry and the ability to program location rates removed the heretofore logistical constraints of simultaneous radio-tracking large far-ranging animals (Rodgers et al. 1996). Accordingly, we employed GPS telemetry to locate deer simultaneously in order to examine the spatial interactions of yarded deer using areas overlapping those of other deer.

Materials and Methods

We conducted this study in the Garden Lake and Isabella deeryards in northwestern Lake County, Minnesota (48°N, 91°W) near the northern edge of deer range (Nelson and Mech 1981, 1987). Each deeryard encompassed approximately 30 km² with minimums of 6-17 deer/km² at Isabella (Nelson and Mech 1986a) and > 17 -34 deer/km² at Garden Lake (M. Nelson, unpublished). Most (83%) deer annually migrate a mean of 12 km \pm 1.2 SE, (Isabella) and 25 km \pm 1.8 SE (Garden Lake) between summer and winter home ranges (Nelson and Mech 1987). Topography is flat, glaciated

Canadian Shield dominated by lakes and rivers (Heinselman 1996). Forests are mixtures of aspen (*Populus tremuloides*), Jack Pine (*Pinus banksiana*), and spruce (*Picea* spp.) (Heinselman 1996). Temperatures remain $< 0^{\circ}\text{C}$ November–March, and weekly snow depths average 30 cm and 50–64 cm during 48% and 52% of winters respectively (Nelson and Mech 2006). Hunting and Wolf (*Canis lupus*) predation are the primary causes of deer mortality (Nelson and Mech 1986b). Supplemental feed provided by recreational feeding is available to deer in both deeryards.

We captured adult female deer in Clover traps (Nelson and Mech 1981), extracted an incisor (Nelson 2001) for aging, and fitted them with Advanced Telemetry System (ATS, Isanti, Minnesota) releasable GPS radio-collars (Merrill et al. 1998) programmed to obtain 1 location per hour. Positional accuracy was < 50 m for 50% and < 100 m for 85% of locations, respectively (Bowman et al. 2000). We remotely released the collars from deer and downloaded locations to a computer for spatial analysis.

We restricted our analyses and comparisons to pairs of deer that used overlapping areas. From pairs of locations with the same date and hour, we derived 95% fixed-kernel areas (Worton 1989, 1995) for each deer, calculated with least-squares cross-validation using the Animal Movement (Hooge et al. 1999) and Spatial Analyst extensions in the software ArcView GIS (version 3.3, Environmental Systems Research Institute, Inc., Redlands, California).

We used three approaches to examine the spatial interactions between these pairs. First we looked for evidence of deer traveling together to determine if they were associated. We considered paired locations < 100 m apart during several hours of movement to be evidence of travel together and some type of association.

Secondly, we assumed that the most likely evidence of deer interaction would be found in the areas deer shared at the same time. Auditory, olfactory, and visual contact could all potentially play a role in deer interactions and manifest their influence in the distance between deer. If two deer interacted by being attracted to, or avoiding each other, then distances between them at the same time should be smaller or larger respectively, than distances between random pairs of locations recorded at different times. Therefore, we computed distances between locations recorded ≤ 1 minute apart inside areas of overlap and used the method described by Chamberlain and Leopold (2000) to compare the distribution of distances among three classes (< 100), < 100 – 200), and > 200 m) with the distribution expected if deer traveled independently. We used R software (R Development Core Team 2005) to implement our analysis.

For the third and final test for spatial interaction, we used proportions of locations spent individually and simultaneously within overlap areas shared by pairs

of deer to estimate probabilities of individual and joint use. When individuals use overlap areas independently, probabilities of joint use should equal products of probabilities of individual use (Powell et al. 1997). We used chi-squared goodness-of-fit tests to compare observed numbers of instances of joint use with numbers expected if deer used overlap areas independently. Because successive locations of individual deer probably were not independent, our test results likely underestimated Type I error rates (probabilities of detecting association or avoidance when deer used overlap areas independently).

Results

We captured and attached GPS collars to nine adult female deer during 2 February – 9 April 1999 (Table 1). This allowed seven pair-wise comparisons (median = 14 days) of deer radio-tracked at the same date and time and with overlapping home ranges (Table 1). The GPS collars successfully acquired 69–99% (median = 89) of all potential locations during the tracking periods we compared. Simultaneous locations yielded 90–99% (median = 94.2) of the locations available for such comparisons.

Deer were located < 100 m apart $< 15\%$ of the time during 1940 pairs of locations from all deer. In examining locations chronologically, we found no evidence of pairs of deer being located and traveling together.

Five pairs of deer had 33, 40, 50, 79, and 88 locations (≤ 1 minute apart) within overlapping areas. We found no evidence that deer were located close together (within < 100 or 100 – 200 m) or far apart (> 200 m) more frequently than expected if they used overlapping areas independently ($\chi^2_2 = 0.6$ – 4.5 , $P = 0.10$ – 0.73). Small sample sizes for two pairs of deer precluded interpretation of their results.

All pair-wise comparisons of overlap between deer indicated deer occupied overlapping areas at the same time during 1.8–27.0% (median = 16.8) of locations, and used their overlaps as expected if they moved independently of each other ($\chi^2_1 = 0.01$ – 1.5 , $P = 0.22$ – 0.91).

Discussion

None of our deer were family members or members of the same social group as evidenced by them traveling separately. Our analyses of distances between simultaneously located pairs of these deer in their overlap areas, and probabilities of using overlapping areas, suggested they moved independently of each other. It is unknown if our overlapping pairs of deer had conflicts at recreational feeding sites they shared. However, if there were such interactions there as well as elsewhere, their effects did not manifest themselves in the distances between deer and their use of overlapping area. Contrary to this, Gavin et al. (1984) speculated that agonism possibly acted as a spacing mechanism among Columbian White-tailed Deer (*O. v. leucurus*),

TABLE 1. Deer ages, tracking periods, simultaneous (same hour and day) locations estimating 95% fixed-kernal areas, and area overlap for seven comparisons of nine yarded female deer in northeastern Minnesota 2 February to 9 April 1999.

Deeryard	Comparison deer number	Age yrs	Tracking periods	Snow depth (cm) start	Snow depth (cm) end	Days	Locations	95% Kernal Area (ha)	Overlap Area (ha)
Isabella	7862	2	2-17 February	46	53	15.2	274	99	20
	7864	12						20	
	7864		11 February-15 March	46	69	31.8	496	16	12
	7872	3						49	
	7862		11-17 February	46	53	6.2	109	28	7
Garden Lake	7872							35	
	7840	5	1-9 April	15	10	8.6	164	28	8
	7924	10						22	
Deeryard	7908	10	18-31 March	43	20	13	249	52	19
	7924							48	
	7920	8	17-31 March	43	20	13.7	263	89	38
	7922	4						64	
	7920		19 March- 8 April	43	10	19.8	385	31	15
Median	7928	1						70	
		5						42	15
		1						16	7
		12						99	38

similar to home range defense exhibited by Black-tailed Deer (*O. hemionus columbianus*, Miller 1974) and parturition territoriality by maternal White-tailed Deer (Ozoga et al. 1982). However, Nixon et al. (1991) found no evidence for defense of space by wintering deer in Illinois. They observed spatial tolerance among socially separate White-tailed Deer bedding within 100 m of each other after prior aggressive interactions. Similarly, 30 beds of yarded deer in northern Wisconsin were observed close to each other near a supplemental feeding site where deer competed aggressively for food (Kabat et al. 1953). We also observed large numbers of yarded deer bedding 10-50 m from each other on lakes adjacent to recreational feeding sites. This was a unique situation due to extremely deep snow (95 cm) in the woods, but nonetheless consistent with our results indicating that yarded deer tolerated unrelated deer nearby. Conceivably our deer with overlapping areas might have aggressively competed for naturally occurring food similar to competition for supplemental food. However, our observations of deer using baited capture sites in previous studies indicated deer were displaced only short distances (5-10 m) by dominant deer. Thus the spatial effect of feeding competition is likely limited to the specific site and time.

Hirth (1977) observed high social tolerance and grouping behavior throughout the year by Texas deer living in an open grass-shrub environment. Maternal females there increased their agonistic behavior and isolated their young fawns but rejoined their social groups and other deer daily after tending their fawns. Thus, females displayed social intolerance in one context while simultaneously being social in another. This is analogous to that of yarded deer tolerating the presence of other deer while being agonistic when directly competing for food. Both examples reflect a deep-seated propensity for social grouping, which likely evolved as a defense against predation (Hirth 1977; Nelson and Mech 1981; Messier and Barrette 1985; Geist 1998). Deer close to other deer benefit from the vigilance of other deer, share the risk of being detected or killed, and when forced to flee predators, their multiple escape paths and motion may confuse predators.

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Pileated Woodpeckers, *Dryocopus pileatus*, Foraging in Suburban Habitats in New Brunswick

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Erskine, Anthony J. 2008. Pileated Woodpeckers, *Dryocopus pileatus*, foraging in suburban habitats in New Brunswick. Canadian Field-Naturalist 122(3): 226-229.

Pileated Woodpeckers (*Dryocopus pileatus*), usually woodland birds, were seen often in Sackville, New Brunswick, in winters 2005-2007. Excavations in trees were made mostly by two female birds. A male bird joined each female briefly in late winter. These birds probably all roosted in wooded areas west of town. Most large trees in town are broad-leaved, in contrast to the mostly conifer woods to the west (there are only open lands to the east). Feeding excavations in town were mostly in maples, with little use of elms. Prey noted were large larvae, seemingly of sawflies, unlike published reports of Pileated Woodpecker feeding mainly on adult ants and beetles. Excavations further weakened trees already damaged by boring insects, causing perceived risks to passers-by and to overhead wires. Work by woodpeckers alerted arborists to weakened trees or branches, many of which were removed. Local people were excited at seeing, close up, these impressive – and tame – birds.

Key Words: Pileated Woodpecker, *Dryocopus pileatus*, foraging, suburban habitats, New Brunswick.

Pileated Woodpeckers (*Dryocopus pileatus*; PIWO hereafter) are thought of as woodland birds (Bent 1939). In over 50 years, I only twice encountered the species foraging in sight of houses, before they invaded Sackville, New Brunswick (45°50'N, 64°15'W; human population 5500), in autumn 2005. As reports accumulated, it seemed that one or several individuals here were not always behaving as described in publications on the species. This study thus started from curiosity about novel behaviour.

Study Area and Methods

Built-up parts of Sackville adjoin the Tantramar dykeland, formerly saltmarsh, the largest treeless area in Canada's Maritime Provinces (Figure 1). The site slopes gradually upwards to the west, into largely continuous forest that formerly included the area where the town now stands. The town limits were greatly enlarged in 1974, and now include several formerly separate villages (Middle Sackville, Upper Sackville and Mount View to the north; Frosty Hollow to the south).

Nearby forest is mixed, with conifers (mostly *Picea* spp. and *Abies balsamea*) predominating in a "fog belt" around the upper Bay of Fundy. Trees in town, planted, are largely broad-leaved, including especially maples (*Acer* spp.) and elms (*Ulmus* spp.). Those plantings line streets in older residential areas and around Mount Allison University; more recent housing developments and industrial areas often have few trees and no mature ones.

Study was mainly observational, often following up reports by other people. Actual sightings of the woodpeckers were far outnumbered by their excavations. The latter were monitored at irregular intervals, which

varied with distance from my home. As records accumulated, I searched areas without reports around known PIWO sites. Except on the university campus and in town parks, my searches were mostly in areas viewed from streets. Chips, easily visible on grassy lawns and sidewalks (which were seldom snow-covered in those winters), could often be detected from a distance of 30+ metres. The study spanned nearly two years from my first sighting (12 November 2005), including winters of 2005-2006 and 2006-2007. No obvious differences between years were noted, so data from both years were combined.

Results

PIWO were active in Sackville mainly between early November and late March 2005-2007 (Table 1), and were not seen there before or since. Most chronological evidence was from freshly cut chips and excavations, distinguished from those of other woodpeckers by size, as sightings of birds were infrequent and unpredictable.

The accumulated distribution of PIWO activity in Sackville (Figure 1) involved two well-separated areas. Most activity was seen in built-up areas of the old town, with minor use also detected in Middle and Upper Sackville. The old town included some 90 trees worked, to varying degrees, by PIWO, with about 12 trees used in the northern area. Diggings were mostly in live wood (as judged from chips) of large, live trees (Tables 2,3), often in relatively well-treed areas.

Trees used by PIWO in Sackville were mostly maples (Table 4), especially Norway Maples (*Acer platanoides*), which may be planted more often than other maple species. Elms, which included most other large trees in town, were little used, although many

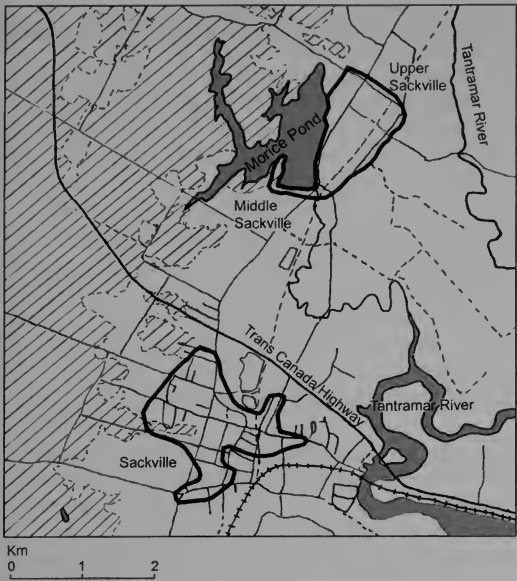


FIGURE 1. Location of study area in Sackville, New Brunswick. Areas of Pileated Woodpecker activity in 2005-2007 outlined (heavy lines). Main built-up area of Sackville ("old town") roughly corresponds to the southern activity area of woodpeckers. Areas of more-or-less continuous woodland (west of town) are shown by diagonal hatching; note "corridor" of woodland connecting forest to built-up area of "old town" (assumed to be route by which woodpeckers entered and left "old town"). Unhatched areas to east of town are treeless dyked grasslands.

were dead, dying, or in poor condition. The old maples used were nearly all alive, though some had upper trunks or a few large branches dead. Evidence from PIWO diggings indicated that many mature maples were infested by larvae of wood-boring insects, some of which were seen (by other people) as the birds extracted them. Some larvae, and one adult, collected from a PIWO-worked tree, were identified as sawflies (Hymenoptera; per R. Aiken, Biology Department, Mount Allison University).

PIWO use of urban trees in Sackville was apparently restricted to foraging. Many trees were investigated by PIWO, often resulting in only a few chips or small excavations. Others were subjected to intensive excavation during two to three weeks, producing large piles of chips (up to 15 cm deep by 60 cm across) while creating cavities extending up to 1.5 metres along and halfway through a trunk (Table 5). In a few cases excavations from opposite sides of a tree met in the middle, and some trees were undoubtedly weakened by PIWO excavations.

No reports suggested PIWO activity focussed in any particular areas in early morning or late afternoon,

TABLE 1. Timing of excavation activity of Pileated Woodpeckers, Sackville, New Brunswick 2005-2007.

Month	Number of trees with observed activity	
	earliest	latest
September (2006 only)*	1	
October (2006 only)*	4	
November	14	
December	28	3
January	5	36
February	2	19
March	1	15
April		9
May		3
unknown		4

*reported after activity ended.

TABLE 2. Estimated heights of trees worked by Pileated Woodpeckers and heights of their excavations, Sackville, New Brunswick, 2005-2007. (Trees worked in both years were counted only once, but excavations in them may appear more than once).

Height (m)	Number of trees	Number of excavations
0-2		15
2-4	1	41
4-6	1	37
6-8	1	14
8-10	5	5
10-12	4	3
12-14	9	8
14-16	26	
16-18	34	
18-23	2	
not estimated	8	22

TABLE 3. Diameters (breast height) of trees worked by Pileated Woodpeckers, Sackville, New Brunswick* 2005-2007

Diameter (cm)	Number of trees
≤ 40	4 (1)
41-50	30
51-60	22 (3)
61-70	26
71-80	7 (2)
>80	6 (1)
not estimated	12

* Numbers in parentheses from Middle/Upper Sackville, others in main built-up area of Sackville.

as would be expected if the birds roosted in town. On two occasions PIWO were seen in late afternoon flying away from diggings in a westerly direction (towards the continuous woods). No evidence of nesting in built-up areas of Sackville was found or reported in the study

TABLE 4. Tree species winter usage by Pileated Woodpeckers, Sackville, New Brunswick* 2005-2007

Tree species	Number of trees worked with excavations				Total *
	large	medium	small	chips only	
Norway Maple <i>Acer platanoides</i>	10 (3)	17 (2)	29 (2)		56 (7)
Sugar Maple <i>Acer saccharum</i>		2			2
Red Maple <i>Acer rubrum</i>	1	2		1	4
Silver Maple <i>Acer saccharinum</i>	1	3	(1)		4 (1)
Manitoba Maple <i>Acer negundo</i>		1	5		6
Maple <i>Acer</i> spp.?	4	3	5	1	13
Sub-total					85 (8)
Elm <i>Ulmus</i> spp.?	1	2	2	6	9
Linden <i>Tilia</i> spp.?				1	1
Trembling Aspen <i>Populus tremuloides</i>			(1)		(1)
Sub-total					10 (1)
Stub (spp.?)			2		2
Totals	17 (3)	30 (2)	43 (4)	9	97 (9)

* Numbers in parentheses from Middle/Upper Sackville, others from main built-up area of Sackville.

area, where several observers in the second Maritimes Breeding Bird Atlas were active throughout breeding seasons of 2006 and 2007.

Most sightings were of single birds, those determined to sex being females only, until late February 2006. Two sightings in each winter, all in late February to April, involved two birds each, confirmed (once each year) as a male near a female. These "pairs" foraged in the same tree, but were not seen to interact in other ways. On 3 March 2006, in late afternoon (16:05-16:15 AST), both birds departed independently in the same direction, into a "corridor" of woodland extending westward to the forest.

Public concern was sometimes expressed about "damage to apparently sound trees". One property owner tacked sheet-metal across a large cavity to deter further PIWO activity! Utility companies, the university, and some land-owners thought it necessary to have trees removed before they could fall through wires or onto buildings, vehicles or people. My notes indicated that at least 25 PIWO-worked trees were felled between March 2006 and August 2007, vs. only one such tree that fell naturally (in a windstorm) during that period.

Many people were excited to see these large woodpeckers in town, where no previous sightings were known to local bird students. The birds were not at all shy, often allowing approach within a few metres – for viewing or photography.

TABLE 5. Estimated volumes of tree excavations by Pileated Woodpeckers, Sackville, New Brunswick* 2005-2007

Volume (litres)†	Number of excavations
<1	41 (1)
1-2	15 (1)
2-3	9
3-4	8
4-5	6
5-7	9
7-9	5 (1)
9-11	6
11-15	4 (2)
>15 (max. 33)	6

* Numbers in parentheses from Middle/Upper Sackville, others from main built-up area of Sackville.

† Volume figures were derived as follows:

(i) measurements (cm) were taken (or estimated, for high excavations) of tree diameter at excavation (DX); vertical length (LX) and horizontal width (WX) of excavation.

(ii) cavity was assumed roughly triangular in horizontal section [area of triangle $(1/2 bh) = 0.5 WX \times 0.5 DX$]; thus volume (of triangular prism) = $(0.5 WX \times 0.5 DX) \times LX$, in cubic centimetres = litres/1000.

Discussion

The only published works found on PIWO in the northeast (Flemming et al. 1999; Kellam 2003) treated foraging habitat in summer and behaviour in fall, respectively. Given the low density of PIWO in this

region, and the difficulty of continued observations of them in their usual forested habitats, the scarcity of studies is not surprising. The present study may be the first on winter foraging near PIWO's northern range limit, but findings in this peripheral area may not all represent behaviour typical of the species elsewhere in its range.

Earlier studies, mostly in east-central or western USA (summarized by Bull and Jackson 1995), found nesting and roosting usually in the same "territory", used also for foraging. Existing pairs were closely associated in roosting and nesting activities. The present study, based on small numbers of birds, found regular foraging by single birds, in areas apparently used neither for roosting (in winter) nor for nesting (in summer).

Females here usually foraged alone in winter, in suburban habitats not reported as used regularly elsewhere in this region (Erskine 1992). They were joined there by males only in late winter (February–April). That timing might reflect first pairing by females that failed to establish foraging territories in typical woodland habitats in their first autumn? Males might follow such females from roosting areas to foraging habitats for purposes of pair-formation. Use of large suburban parks (with similar habitats) in Europe by the congeneric Black Woodpecker (*Dryocopus martius*) is not unusual (personal observations in West Berlin 1978), so might become more frequent in PIWO in future.

Studies of PIWO in other northern (and mountain) regions mostly involved conifer habitats, where nesting, roosting, and feeding largely occurred in dead trees. In the present study, most foraging activity was in live broad-leaved trees, especially maples – with relative avoidance of elms, despite frequent poor health of the latter. This suggested deliberate focus by PIWO on a particular food (sawflies), which might be specific to maples, or be occurring only during an outbreak of that prey organisms.

Work elsewhere also emphasized feeding on particular species (adult carpenter ants or wood-boring beetles) (Bent 1939; Bull and Jackson 1995), but the few observations of prey noted here (by D. Bliss and K. Bunker-Popma, personal communications) suggested that larval insects were important foods – as implied also by the extensive excavations. Such soft-bodied prey likely were under-represented in earlier food studies that relied on gizzard analyses.

The present study expanded the known range of behavioural strategies used by this species – although some of these may be characteristic only of this study area and period. It also revealed widespread interest in, and concern of, the public with activities of these impressive birds, when their activities extended into suburban habitats where they were easily observed.

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A shorter version of this paper was presented at the September 2007 conference of the Society of Canadian Ornithologists, at Chaffey's Lock, Lake Opinicon, Ontario.

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Evidence of Arboreal Lichen Use in Peatlands by White-tailed Deer, *Odocoileus virginianus*, in Northeastern Alberta

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Latham, A. David M., and Stan Boutin. 2008. Evidence of arboreal lichen use in peatlands by White-tailed Deer, *Odocoileus virginianus*, in northeastern Alberta. *Canadian Field-Naturalist* 122(3): 230-233.

Within the past 10 to 15 years, White-tailed Deer (*Odocoileus virginianus*) have extended their geographical range to include most of northern Alberta. In the boreal forest they are most abundant in well-drained upland habitat. We report the occurrence of unusually large numbers of deer seen in a large fen complex in the west side of the Athabasca River Caribou range in northeastern Alberta. Further, we report an observation that suggests that deer may be using arboreal lichen (old man's beard; *Bryoria* spp. and *Usnea* spp.) as a winter food in this region. We discuss the potential ecological ramifications of this observation for Woodland Caribou (*Rangifer tarandus caribou*) in northeastern Alberta.

Key Words: White-tailed Deer; *Odocoileus virginianus*; arboreal lichen; peatlands; range expansion; northeastern Alberta.

Increasing deer populations have become a major force of ecological change throughout many parts of the world (Alverson et al. 1988; Fuller and Gill 2001; Rooney 2001; Côté et al. 2004). In particular, overbrowsing by deer has been shown to drastically alter forest composition and structure, and potentially modify interactions throughout food webs (e.g., Gill 1992; Putman and Moore 1998; Cooke and Farrell 2001; Fuller and Gill 2001; Husheer et al. 2003; Côté et al. 2004). Deer population increases are generally attributed to regulated hunting seasons and quotas, and land management practices that have increased forage availability and reduced predator densities (Nelson and Mech 1986; Alverson et al. 1988; Fuller and Gill 2001; Côté et al. 2004). In addition, warmer winters have been correlated with increased recruitment and overwinter survival of deer, particularly at higher latitudes (Albon et al. 1983), and may be playing a role in the current range extension of some species (Fuller and Gill 2001).

In North America, White-tailed Deer (*Odocoileus virginianus*) populations have shown dramatic range extensions and population increases in recent years (Côté et al. 2004), and have been reported as far north as the Northwest Territories, Canada (Kuyt 1966; Gainer 1995; Veitch 2001; Rue 2003). Although White-tailed Deer are known to use a wide variety of habitats across their range, in their more northerly extent they are particularly associated with aspen parkland and agriculture (Wishart 1984; Nietfeld et al. 1985; Rue 2003). In southern Alberta, Canada, White-tailed Deer numbers increased dramatically during the 1940s and 1950s in response to habitat changes resulting from a series of wet years and an absence of prairie fires (Webb 1967; reported in Wishart 1984). They had become well-established in northwestern Alberta (Peace River

Parklands) by the mid-1980s (Wishart 1984). In northeastern Alberta, however, they appear to have moved north of the agricultural belt only in the last 10 to 15 years (Wishart 1984; Gainer 1995; Charest 2005; Latham 2009). Changes in land management practices, most notably the spread of agriculture and forestry, as well as warmer winters are most often implicated in the northward range expansion of White-tailed Deer in this region (Wishart 1984; Charest 2005).

White-tailed Deer densities within the boreal forest of northeastern Alberta are low compared to most of their range. For example, deer densities of $>7/\text{km}^2$ have been reported from northeastern USA (Alverson et al. 1988; deCalesta 1994) and southeastern Canada (Huot et al. 1984), $1.7 \text{ deer}/\text{km}^2$ have been estimated for the boreal-agricultural fringe region of northeastern Alberta (Alberta Sustainable Resource Development, unpublished data), and $0.7 \text{ deer}/\text{km}^2$ have been estimated for the boreal forest of northeastern Alberta (Latham 2009). Although most frequently found in boreal-mixed forest in northeastern Alberta (James et al. 2004), White-tailed Deer have previously been reported from the extensive peatlands in this region (Found 2007; Latham 2009). Though peatlands likely offer grasses and forbs for deer to forage on during the growing season, there is no information regarding winter food habits of White-tailed Deer in western Canadian peatlands (Wishart 1984). The primary objective of this note is to report the possible use of arboreal lichen as a food source by White-tailed Deer in a large peatland complex in northeastern Alberta during winter.

Methods

We conducted aerial surveys as part of a long-term ungulate monitoring program on the west side of the

Athabasca River (WSAR) Caribou, *Rangifer tarandus*, range in northeastern Alberta during the winters of 2004 to 2007. The WSAR range is approximately 15000 km² of boreal-mixed forest (approximately 40% of the study area) and peatland (approximately 60% of the study area) habitat, and is situated to the east of the town of Wabasca (55°57'N, 113°49'W). Peatland within the range is characterised by Black Spruce (*Picea mariana*) bogs and Black Spruce-Tamarack (*Larix laricina*) fens. Well-drained uplands are characterised by Trembling Aspen (*Populus tremuloides*), White Spruce (*Picea glauca*), Balsam Fir (*Abies balsamea*), and Jack Pine (*Pinus banksiana*). Terrestrial (e.g., *Cladonia* spp. and *Cetraria* spp.) and arboreal (*Alectoria* spp., *Bryoria* spp., and *Usnea* spp.) lichens are common in the study area. See Bradshaw et al. (1995) for a detailed description of vegetation in the study area.

Historically, Moose (*Alces alces*) and Woodland Caribou (*Rangifer tarandus caribou*) were the primary ungulate species found in this region of Alberta, although both occurred at low densities compared with much of North America (Hauge and Keith 1981; Stuart-Smith et al. 1997). Previous research showed that Moose were most abundant in well-drained uplands, while Caribou were found almost exclusively in peatlands (James et al. 2004). Based on aerial transect surveys conducted in the mid-1990s, White-tailed Deer were rare in WSAR (James et al. 2004). Although they have increased in density across much of northeastern Alberta in recent years (Charest 2005; Latham 2009), the vast fen/bog complexes that typify WSAR are considered poor deer habitat (Huot et al. 1984; Rue 2003; James et al. 2004). Mule Deer (*O. hemionus*) and Elk (*Cervus elaphus*) occurred at low densities within small portions of the range (A.D.M. Latham, unpublished data).

We used a fixed-wing aircraft to survey an 8000 km² portion of the WSAR range that included both extensive peatland habitat and well-drained upland habitat. Surveys consisted of east-west transects spaced at 1 (~1850 m) or 2 minute intervals of latitude. A minimum of 2100 km was flown in each survey. Transects were flown at a speed of 80 knots and an altitude of 80 to 110 m above ground level. One observer recorded ungulates seen from the right side of the aircraft, and a second observer recorded ungulates seen from the left. Surveys were conducted after fresh snow fall (>10 cm) during February or early March (survey date was dependent upon snow conditions).

Results

We saw an average of 3.9 (± 0.83 ; 95% CI) White-tailed Deer per 100 km flown in winter, 2004-2007. Approximately 61% of deer were seen in well-drained uplands, while 39% were seen in peatlands. Only in early March 2007 were comparable numbers of deer seen in uplands and peatlands, 41 and 39, respectively. Twenty-five (nine groups) of the White-tailed Deer seen

in peatlands in March 2007 were in large Tamarack and Black Spruce-Tamarack fens between Parallel Creek (west) and the Athabasca River (east) (approximately 55°36'N, 112°50'W). Canopy cover within this fen complex ranged from approximately 10 to 20%. The average distance from the groups of deer in this complex to the Athabasca River was 2.3 km (range: 0.7 km to 3.4 km). Approximately half the deer seen were bedded in and around Tamarack and Black Spruce trees, while the remaining individuals were standing. Observations of two standing deer (from two different groups) suggested that these individuals were feeding on long strands of arboreal lichen hanging from Tamarack trees. Though we were unable to determine lichen species, the most abundant arboreal lichen hanging from trees in peatlands in WSAR is old man's beard (*Bryoria* spp. and *Usnea* spp.).

Discussion

Recent evidence suggests that arboreal lichens may similarly be browsed by White-tailed Deer in uplands during winter in northeastern Alberta. For example, a qualitative assessment of Trembling Aspen-White Spruce forests on the western boundary of WSAR in March 2008 revealed that deer (as determined by tracks and pellet groups) had caused an obvious and extensive browse line on arboreal lichen to a height of approximately 1.6 m (A.D.M. Latham, unpublished data). Further, a young White-tailed Deer buck was observed from approximately 20 m feeding on Old Man's Beard hanging from a White Spruce in this same area in November 2008 (A.D.M. Latham, personal observation). The buck fed for approximately 15 minutes, occasionally standing on both hind legs to feed, before moving off into the forest apparently unaware of any human presence. Similar behavior and browse lines of comparable heights have been reported from elsewhere in North America (Harlow 1984). A quantitative assessment of lichen use by White-tailed Deer in WSAR is required to gain a greater understanding of the magnitude of this phenomenon (i.e., is it widespread or confined to areas where deer yard).

The use of arboreal lichens by White-tailed Deer has been reported on Anticosti Island, Québec, southeastern Canada (Huot 1982), Michigan, USA (Harlow 1984), and the southern Appalachian Mountains (Harlow and Downing 1969). Despite this, it is important to note that in addition to arboreal lichen use, the White-tailed Deer observed in fens during the described survey may also have been utilizing Tamarack and Black Spruce as a food source (Blouch 1984). Although we did not observe deer feeding on these species, they have been recorded as a "last resort" food in Ontario, Canada (Blouch 1984). The comparatively low nutritional value of these tree species suggests that lichens should be preferred (Harlow 1984; Huot et al. 1984). Further, arboreal lichens have greater

digestibility values than many species of conifers and hardwoods (Mautz et al. 1976; Hobbs et al. 1981), possibly because of lower concentrations of plant secondary compounds (Ditchkoff and Servello 1998). Indeed Ditchkoff and Servello (1998) state that "selective foraging for arboreal lichens by deer could significantly raise overall diet quality and reduce over-winter loss of mass".

We are unsure why a higher proportion of White-tailed Deer were seen in peatlands in March 2007 compared with other years. However, the comparatively deep snow (50–60 cm in 2007, compared to 30–40 cm in 2004–2006; E. Christiansen, Alberta Sustainable Resource Development, unpublished data) in 2007 may have necessitated the use of arboreal lichen as a food, and the absence of a crust on the surface of the snow in that year may have facilitated greater access to this food source. Although snow conditions (particularly deep, dense or crusted snow that is unable to support the weight of deer; Kelsall 1969) may cause peatland complexes to be less accessible to deer in some years, it is important to note that low numbers of deer have been reported from peatlands in all of the aerial surveys that we have conducted since 2004 (Latham 2009). Consequently, it is possible that White-tailed Deer may similarly have used lichen as a source of nutrition during previous winters.

As in many parts of the world, there is concern about increasing deer populations in Alberta and their potential to cause substantial ecological change. Whether White-tailed Deer in Alberta have increased because of industrial or agricultural conversion of the boreal forest, various climatic factors, or a combination of all of these factors remains unknown. However, we do know that the boreal forest of northern Alberta roughly delimits the northerly extent of White-tailed Deer range (Wishart 1984; Charest 2005). We also know that White-tailed Deer densities are comparatively low in this region of Alberta (Wishart 1984; Latham 2009). Hence, the boreal forest of northern Alberta is likely marginal habitat for White-tailed Deer, and deer are likely severely food limited during winter in this northern environment. The observation reported here sheds light on a possible survival strategy for White-tailed Deer during harsh winters.

Further, the observation that we report suggests that there is the potential for direct competition for food (i.e., lichen) between White-tailed Deer and Woodland Caribou. Although White-tailed Deer are not common in the more interior portion of the WSAR range, Woodland Caribou are found comparatively close (~2 km) to the Athabasca River (and other areas of adjacent upland habitat) in some parts of the range (Latham 2009). Consequently, direct competition between these two species may occur in areas of spatial overlap, a phenomenon that could result in temporal competitive exclusion of Caribou from portions of otherwise suitable habitat. Historically, Caribou use of peatlands

provided them with a virtual refuge from predation as Moose (primary prey) and Wolves, *Canis lupus*, (shared predator) tended to be most abundant in uplands (James et al. 2004). Any increase in the number of deer (a novel primary prey species) in peatlands may upset the spatial separation strategy employed by Caribou which reduces predation risk (Bergerud et al. 1984; Latham 2009). Consequently, the observation that we report here has important implications to understanding and managing White-tailed Deer range expansion, and lessening their impact in Woodland Caribou systems in northern Alberta.

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Effects of Forest Cover on Fruit Set in the Woodland Herb, *Maianthemum canadense* (Liliaceae)

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Animal pollination has been recognized as an essential ecosystem function that is potentially under various environmental stresses. We investigated the landscape effects of forest cover at multiple spatial scales on the sexual reproductive success of a common woodland herb in North America, *Maianthemum canadense*. This species is a self-incompatible species and pollinated by insects requiring natural landscapes. Nine populations were selected in deciduous forests within agricultural fields of southern Ontario, Canada. We investigated whether fruiting success decreases as forest cover surrounding the plant populations increases at the landscape scale. Forest cover was quantified by the proportion of forest within six different radii from 250 to 1500 m. Analyses showed relationships with the proportion of forest at 750- and 1000-m radii and fruiting success in populations of *M. canadense*. These findings suggest potential local extirpation of *M. canadense* and indicate that forest loss can negatively impact on even some common woodland herbs.

Key Words: Carolinian forest, forest fragmentation, habitat isolation, habitat loss, pollinator, Ontario.

Reproductive success of many plants is negatively affected by habitat loss and fragmentation, and such habitat alterations have the potential to influence the reproductive outputs of plants pollinated by animals (Aguilar et al. 2006). Animal pollination is a critical component of ecosystem services, and most of the animal pollinators require natural landscapes (Daily 1997; Losey and Vaughan 2006). To manage such an essential and threatened function in terrestrial ecosystems, understanding the scales at which the reproductive output of plants is influenced is central to the management of pollination services (Kremen 2005).

In this study, we examined the landscape effects of spatial scale on Canada Mayflower, *Maianthemum canadense* (Desf.) (Liliaceae). This species is a widespread, perennial forest-understory herb with genets of dimorphic ramets (shoots; Silva et al. 1982; Ross and Laroi 1990; McCully et al. 1991; Ganger 2004). Vegetative shoots have a single leaf, and flowering shoots have two or three leaves with a terminal inflorescence of 6 to 40 white flowers (McCall and Primack 1987; Ganger 1997). In eastern Canada, the flowers bloom in late spring and fruits appear in late summer (Helenurm and Barrett 1987). Each fruit contains one to four seeds, and usually only fruit with seeds develop. *Maianthemum canadense* is self-incompatible (Worthen and Stiles 1986, 1988; Barrett and Helenurm 1987; McCall and Primack 1987; Wheelwright et al. 2006) and is pollinated by insects (Thomson et al. 1985; Barrett and Helenurm 1987). Several populations of *M. canadense* in Canada have suffered reductions in sexual reproductive output from loss of pollinators

caused by pesticides used to control forest insect pests (Kevan and Plowright 1995).

Knowing that forests provide potential habitat area for pollinating insects, we quantified forest cover surrounding populations of *M. canadense* and investigated whether forest cover affects sexual reproductive success. We determined whether fruiting success decreases as forest cover increases. If so, we then determined at what scale(s) it is affected.

Methods

Study region

The study was conducted within a restricted geographical area of Norfolk County, Ontario, Canada (42°37' to 42°48'N, 80°25' to 80°39'W), to reduce the potential problems associated with differences in climate (Lipow et al. 2002) and edaphic factors (Mix et al. 2006). This region is located in southern Ontario's deciduous forest ecosystem, the Carolinian forest. The unique warm and dry climate of this region is suitable for this deciduous ecosystem, which is not found elsewhere in Canada. The landscape is rather flat, with patches of forest ecosystems, which were most of the natural ecosystems in the study region, distributed within intensively managed agricultural fields of crops, mainly tobacco, corn, and soybeans (Taki and Kevan 2007; Taki et al. 2008). Many plants with priority for conservation in Canada exist in this Carolinian forest zone (Allen et al. 1990; Argus 1992; Waldron 2003).

Plant selection

Nine populations of *M. canadense*, each existing within varying amounts of forest cover, were selected.

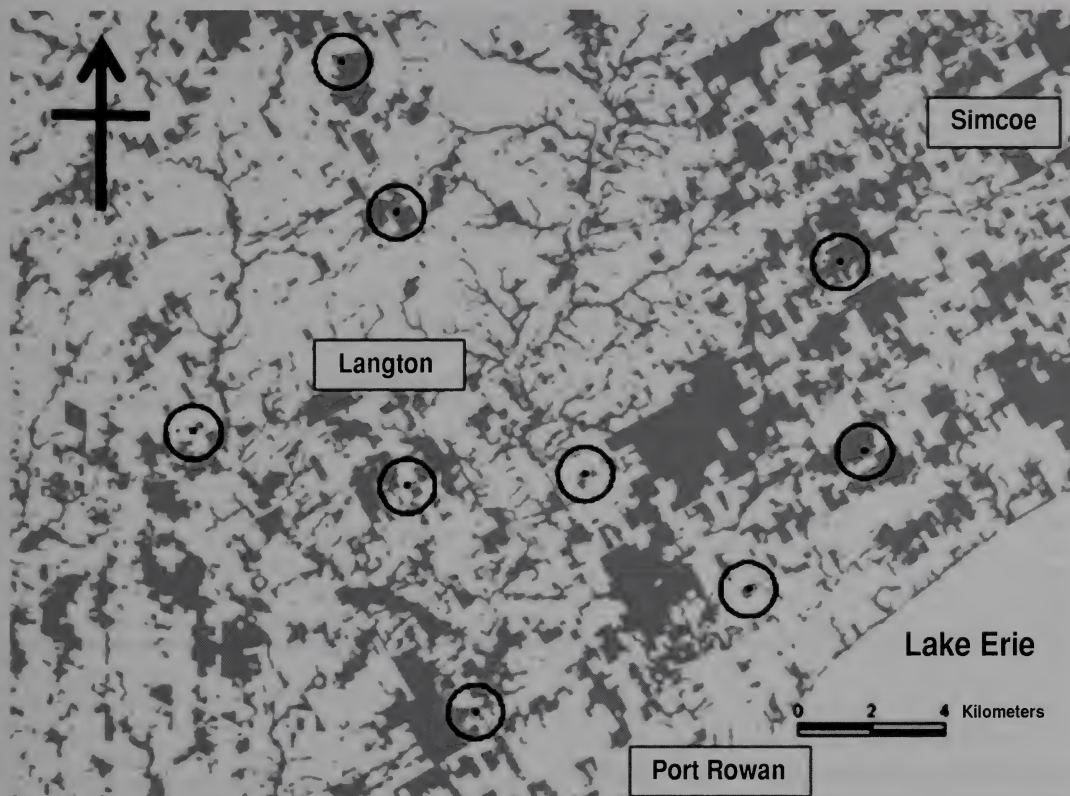


FIGURE 1. Nine study sites of *M. canadense* used to evaluate amounts of forest cover and forest in Norfolk County, Ontario. The 750-m radius, one of the six study scales, is also shown. Shaded areas indicate forested areas. The geospatial data were obtained from the Ontario Base Map Series (Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada).

The study populations had variable numbers of flowering shoots, and the mean number of flowering shoots among the nine sites was 66.2 ± 30 (mean \pm SD), ranging from 40 to 125. To reduce the potential effects of forest edges, all populations were selected at least 30 m from edges of forest patches. All populations of *M. canadense* were selected by 5 May 2004, prior to blooming. They were separated by a distance of at least 4000 m from other study populations. This was ensured with the aid of a global positioning system (GPS; Garmin International, Olathe, Kansas, USA) and a Geographical Information System (GIS), ArcView (version 3.3, ESRI, Redlands, California, USA). The geospatial data on forest cover produced using aerial photography (1:30 000 and 1:50 000) were obtained from the Ontario Base Map Series in 2003 (Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada).

Forest cover

To determine the landscape effects of forest cover, each of the nine populations of *M. canadense* was marked on a map as the center of circles having radii of 250, 500, 750, 1000, 1250, and 1500 m (Figure 1)

to measure the amount of forest surrounding the populations. Within the circles, quantification of forest cover (m^2) was carried out using GPS coordinates obtained from the field sites and ArcView. Forest cover within the circles was then determined and treated as an explanatory variable in the statistical analysis (Table 1). Edges of forest were not actual woodlands in the study region, but we considered those natural lands as forest cover. The selected radii were selected as the scales corresponding to the landscape scale response of solitary bees (Gathmann and Tschamtkke 2002; Steffan-Dewenter et al. 2002), which are one of the major pollinator groups of *M. canadense* (Thomson et al. 1985; Barrett and Helenurm 1987).

Fruiting success

Within each of the nine populations of *M. canadense*, 15 individual shoots with unopened flowers were randomly selected on 13 and 14 May 2004. After blooming, on 19 June, all of the shoots were covered with polypropylene mesh bags (product number ON-6200, InterNet, Minneapolis, Minnesota, USA) with 3-mm square holes to prevent potential damage to fruits by herbivorous mammals and birds. On 29 June,

TABLE 1. Minimum, median, maximum and percentile of forest proportion at six scales.

Radius (m)	Minimum	25%	Median	75%	Maximum
250	0.36	0.53	0.62	0.94	0.99
500	0.18	0.25	0.48	0.74	0.85
750	0.12	0.32	0.47	0.61	0.75
1000	0.15	0.40	0.47	0.57	0.69
1250	0.20	0.39	0.43	0.59	0.68
1500	0.20	0.33	0.38	0.51	0.66

TABLE 2. Relationships between forest proportion, as measured in radii of 250, 500, 750 1000, 1250, and 1500 m, and the success in fruit set per shoot (*p*) of *M. canadense* in Norfolk County, Ontario (42°37' to 42°48'N, 80°25' to 80°39'W). * Significant relationships are evident for the 750m and 1000m radii (*P* < 0.05). *a* and *b* are regression parameters of logistic regression: $\text{logit}(P) = a + bX$. Proportion of explained deviance = (null deviance – residual deviance) / null deviance (Wood 2006).

Radius (m)	Intercept				Slope				Proportion of Explained Deviance
	<i>a</i>	SE	<i>t</i> ₇	<i>P</i>	<i>b</i>	SE	<i>t</i> ₇	<i>P</i>	
250	-0.56	0.93	-0.60	0.57	1.01	1.28	0.79	0.46	0.08
500	-0.99	0.60	-1.66	0.14	2.27	1.10	2.06	0.08	0.37
750	-1.28	0.56	-2.31	0.05*	3.07	1.10	2.78	0.03*	0.53
1000	-1.55	0.64	-2.42	0.05*	3.70	1.32	2.81	0.03*	0.54
1250	-1.47	0.78	-1.88	0.10	3.56	1.65	2.17	0.07	0.39
1500	-1.19	0.88	-1.36	0.22	3.12	1.97	1.59	0.16	0.25

shoots with ripe fruits among the selected 15 shoots were recorded at each site. All fruits were taken to a laboratory at the University of Guelph, Ontario, where they were dissected and checked for the presence of developed seeds. To quantify the success of fruit set in each population, the proportion of shoots exhibiting fruits with developed seeds was then calculated for each set of 15 shoots.

Statistical analysis

Before we tested for landscape effects of forest cover on the fruiting success of *M. canadense*, a logistic regression analysis was used to examine the relationship between population size, indicated by the number of flowering shoots, and fruiting success (Faraway 2006; Crawley 2007). We used a quasi-binomial distribution rather than a binomial distribution to avoid over-dispersion problems (Faraway 2006; Crawley 2007). The number of flowering shoots was transformed to avoid high leverage problems (Quinn and Keough 2002). We used logarithmic transformation rather than square-root transformation because logarithmic transformation effectively reduced the frequency of a few populations that were quite large (Legendre and Legendre 1998). A logistic regression analysis was then performed to examine relationships between the proportion of forest and the fruiting success of *M. canadense*. Statistical computations were performed using R Ver. 2.4.1 (R Development Core Team 2006*). For all analyses, a Type I error rate of 0.05 was used.

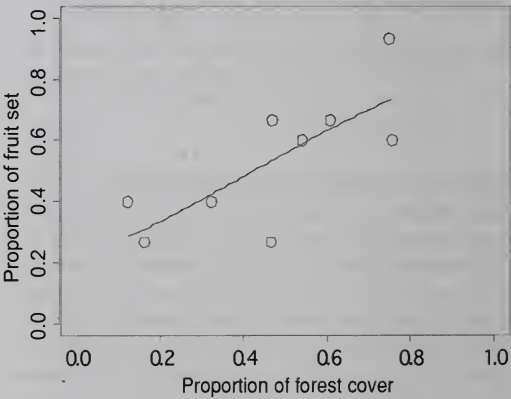


FIGURE 2. Relationship between forest cover measured with in a circle radius of 750 m and the success of fruit set in *M. canadense* in Norfolk County, Ontario. Regression analysis shows $\text{logit}(p) = -1.28 + 3.07X$, $t_7 = 2.78$, $P = 0.03$. A similar trend was found for forest cover measured within a radius of 1000 m.

Results

Logistic regression analysis indicated no significant relationship between fruiting success in *M. canadense* and the number of flowering shoots in a population (proportion of explained deviance = 0.04, slope = -0.46, SE = 0.80, $t_7 = -0.57$, $P = 0.59$). Logistic

regression analysis indicated significant relationships between proportion of forest within radii of 750 m ($t_7 = 2.78$, $P = 0.03$; Figure 2.) and 1000 m ($t_7 = 2.81$, $P = 0.03$) and the success of fruit development in populations of *M. canadense*, although there was no significant relationship at radii of 250, 500, 1250, and 1500 m ($P > 0.05$; Table 2).

Discussion

We recognize that measurement of pollination success may not have been ideal in this study. A flowering shoot of *M. canadense* has a terminal inflorescence with multiple flowers. The observed reproductive output does not indicate fruit set per flower on each shoot because flowers per shoot were not counted in this study. However, our measurements represent sexual reproductive success adequately for investigating the effects of different forest environments on conservation issues at the landscape scale.

We found a significant relationship between forest cover at radii of 750 and 1000 m and fruiting success of *M. canadense*. The radii of 750 and 1000 m were used to measure the proportion of forest. *Maianthemum canadense* is self-incompatible, and it requires insect pollinators, such as hoverflies (Diptera: Syrphidae) and bees (Hymenoptera: Halictidae, Andrenidae and Apidae) to set fruits and seeds. Insect pollinators require habitat for nesting and mating as well as for their food sources (Buchmann and Nabhan 1996; Kearns et al. 1998; Kevan 1999). Loss of forest area within a radius probably reflects the distance containing the habitats of insect pollinators of *M. canadense*. Although we did not observe the abundance of flower visitors to our study populations of *M. canadense*, forest cover would likely influence to these insects. For example, Taki et al. (2007) found that the abundance and species richness of bees collected in pan traps in nearby sites and forest cover at the scale of the 750-m radius showed a significant relationship. Our findings also indicate that the consideration of the pollinators in Acadian and boreal forests, where *M. canadense* is found, are necessarily the same as those in the Carolinian zone of Norfolk.

Although *M. canadense* can maintain large populations through genets consisting of multiple clonal ramets, maintaining and increasing genetic diversity in *M. canadense* populations rely on pollen exchange. Seed dispersal by animals also positively influences genetic diversity in plants of other disturbed habitats (Ibrahim et al. 1996; Austerlitz and Garnier-Géré 2003), but dispersal is contingent on satisfactory fruit set through pollination. Therefore, lack of sufficient pollination could directly and indirectly impede genetic diversity in populations of *M. canadense* inhabiting areas with high loss of forest cover. This may become an issue concerning local extirpations of *M. canadense*; therefore, as in another clonal species of *Maianthemum* in Europe (Honnay et al. 2006), it would be inter-

esting to investigate the effects of forest loss and on genetic variation within and among populations as an indication of the potential for an extinction vortex. For instance, pollinators could be abundant at a site but be less effective because of lack of genetic variants among the plants. Our results suggest a relationship that may be explained by the effect of forest loss and suggest that presence of *M. canadense* may not necessarily assure population persistence of *M. canadense* in fragmented landscapes. Some populations of *M. canadense* may be "living dead" (Tilman et al. 1994) populations that are already on their way to extinction. If so, maintaining *M. canadense* would require restoring forests in order to recover pollinators before extirpation of *M. canadense* occurs (Hanski and Ovaskainen 2002; Bulman et al. 2007).

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Habitat Use by the Eastern Sand Darter, *Ammocrypta pellucida*, in Two Lake Champlain Tributaries

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The Eastern Sand Darter (*Ammocrypta pellucida*) is endangered or threatened throughout much of its range, which includes the St. Lawrence-Lake Ontario drainage of southern Ontario and Quebec and several Vermont tributaries of Lake Champlain. The species is known for its tendency to burrow, and field observations have suggested that habitat use may depend on substrate particle size. To determine whether Eastern Sand Darter densities were correlated with substrate particle size, fish and substrates were sampled in 156 plots in two Vermont rivers during the summers of 2001 and 2002. The Eastern Sand Darter occurred mainly in areas in which substrate composition was over 45% fine to medium sand (0.24-0.54 mm); they were much less abundant in areas in which substrate composition exceeded 25% particles greater than 1.9 mm. Substrate preference was tested by allowing 49 fish kept in aquaria to choose among four different substrates. The fish showed a significant preference ($P < 0.005$) for the finer substrate categories (0.24-0.54 mm, 0.55-1.0 mm), and mostly avoided the coarser substrates (1.0-1.9 mm, 2.0-4.1 mm). This suggests that the Eastern Sand Darter is selective regarding substrate composition, and therefore might be affected by fluctuations or changes in substrate composition within its habitat, such as those caused by changes in flow.

Key Words: Eastern Sand Darter, *Ammocrypta pellucida*, habitat, substrate choice, Poultney River, Winooski River, New York, Vermont.

The range of the Eastern Sand Darter (*Ammocrypta pellucida*, Percidae) extends from the St. Lawrence River and the Lake Champlain drainage to southwestern Ontario, southeastern Michigan, and throughout much of the Ohio River basin to West Virginia and Kentucky (Page 1983; Smith 1985). The Eastern Sand Darter is generally rare throughout its range, and is usually found in streams and rivers with sand substrate, but not in areas with silt or mud (Smith 1985). Daniels (1993) observed that sand darters in the Mettawee River, New York, were found only in areas where substrates were at least 90% sand, and 90% of all sand darters in an artificial stream selected sand (0.25-0.5 mm particle size) over gravel (1-2 cm) or rubble (8-15 cm).

The Eastern Sand Darter burrows in sandy substrates, which may help the fish hold position and conserve energy in unstable sandy habitats (Daniels 1989). The burrowing behavior makes the species sensitive to siltation, which can decrease oxygen availability and may affect prey availability. Drake et al. (2008) found that growth rates of age-0 Eastern Sand Darter were higher in sand-dominated substrates than in silt-dominated substrates. This sensitivity to clean, sandy substrates makes the Eastern Sand Darter a good indicator of habitat quality.

Historical information suggests that the Eastern Sand Darter was common in tributaries of both the Ohio and St. Lawrence rivers (Page 1983), but its distribution and abundance have decreased throughout much

of its range, perhaps due to habitat degradation (Trautman 1957, 1981). Agricultural and industrial pollution, channelization, the creation of impoundments, and land use practices such as removal of riparian vegetation and urban/suburban development which increase erosion and runoff all potentially alter the substrate composition within rivers (Clay 1975; Smith 1979). As a result, formerly sandy areas that had supported sand darters may no longer be suitable, resulting in declines in local populations (Scott and Crossman 1973; Smith 1985; Daniels 1993; Holm and Mandrak 1996; Grandmaison et al. 2004*; Drake et al. 2008).

The declines in Eastern Sand Darter populations associated with increased sedimentation and other human impacts have resulted in the species being classified as globally rare (G3) and receiving protected designations in the Canadian provinces of Ontario and Quebec (COSEWIC 2008*; Drake et al. 2008), and several U.S. states including Vermont, New York, and Michigan (Grandmaison et al. 2004*). However, the development of management or recovery plans has been hampered by the lack of fundamental biological information such as life history characteristics and habitat requirements. Field observations suggest that the Eastern Sand Darter does not use all sandy habitats equally, and that it is more likely to be found in shallow areas with low current velocity and soft, fine to medium sand (Facey 1998). The objective of this study was to characterize the sediment particle sizes preferred by the Eastern Sand Darter more precisely than

Daniels (1993) in order to provide information pertinent to long-term habitat management for the benefit of the species.

Materials and Methods

The study utilized two different Lake Champlain tributaries. The Poultney River forms part of the border between New York and Vermont and flows into the south end of Lake Champlain, and the Winooski River drains a large portion of central Vermont and empties into Lake Champlain north of the city of Burlington.

Between 30 July and 7 August 2001, we sampled substrate and fish from 99 plots within a 1.6-km stretch of a meandering section of the Poultney River upstream from the mouth of the Hubbardton River (43°37'35.93"N, 73°20'34.35"W). The sampled section was generally 10-20 m wide, shallow, sandy, and meandering with steep, sandy banks. Between 3 June and 25 July 2002 we sampled substrate and fish in 57 plots within a 10-km stretch of the Winooski River downstream from the city of Winooski, Vermont (44°29'18.64"N, 73°11'21.27"W). This stretch of the river is mostly 30-50 m wide with a deep channel, but there were shallow areas near islands and along the depositional bank in meandering sections.

In both river sections we sampled all available areas less than 0.5 m in depth and with surface velocities less than about 0.5 m/sec. Deeper or faster areas were not sampled because these conditions make it too difficult to keep the seine on the substrate, which is necessary to capture sand darters. Most sample plots were 3 m × 10 m, but in some cases plot size varied slightly due to water depth or the presence of obstructions in the river. In all cases, substrate composition appeared quite homogeneous within each plot. A single substrate sample from each plot was collected in a 200-ml container from the top 4-6 cm of the substrate of an area representative of the substrate surface composition of the entire plot. Each plot was seined once, always moving upstream, with either a 4.76 mm mesh straight seine (32 plots in the Poultney River) or a bag seine with 6.35 mm mesh wings and 4.76 mm mesh collecting bag (all other plots). The number of individuals of each fish species caught was recorded, and the standard length (mm) of all sand darters was measured.

A chi-square analysis was employed to determine if there was evidence of non-random habitat selection. We assumed that if the Eastern Sand Darter randomly selected habitats, then the distribution of plots with a certain number of fish would resemble a Poisson distribution. In addition, any trends between substrate composition and the number of sand darters captured were noted. Each of the substrate samples was dried and separated into different substrate size components by sifting through a series of sieves. The sieve screen sizes were #5 (4.1 mm), #10 (1.9 mm), #18 (1.0 mm), #35 (0.54 mm), #60 (0.23 mm), and #120 (0.12 mm). Once

separated, each size component was weighed and the percent composition by weight was calculated. Plots were grouped based on sand darter densities, and average percent composition for each particle size was determined for all the plots that had the same density of sand darters.

From late August through early October 2002, we observed substrate choice by 49 Eastern Sand Darter kept in 37.9 L aquaria. Each week seven to 10 fish were collected from the Winooski River, returned to the lab, and maintained in three aquaria. The bottom of each aquarium was divided into four equal quadrants using 2-cm high plastic dividers, and each quadrant received a 2-cm layer of substrate, either 0.23-0.54 mm, 0.55-1.0 mm, 1.1-1.9 mm, or 2.0-4.1 mm in size. Finer sediments were not used because the particles would not remain settled due to fish activity and a slight current created by the filter. To reduce the potential impact of stimuli outside the tank affecting the substrate choice by fish within each tank, the arrangement of the quadrants with different sizes of substrate was different in the three tanks. During daylight hours, all fish in each tank were observed approximately every 2 hours and the substrate size of the fish's location and whether or not it was burrowed were recorded. If the fish was not visible, we assumed it had burrowed and we used a plastic pipette to gently agitate the substrate until the fish emerged. We observed the fish daily for one week, and then returned them to the river. To determine whether the Eastern Sand Darter showed a preference for substrate consisting of certain sized particles, we performed a chi-square analysis using fish locations in one randomly chosen observation period for each group of fish, thereby preventing the use of multiple observations of a single individual.

Results

A total of 42 adult Eastern Sand Darters (48-57 mm SL) was captured from the Poultney River plots. Eighty plots had no sand darters, nine plots contained one, six plots had two, two plots contained four, one plot contained six, and one plot had seven sand darters. The 42 sand darters caught in the 99 different plots did not follow a Poisson distribution (chi-square = 17.85, $P = 0.00002$, 1 df). To perform the chi-square analysis and maintain an expected value above five for each category, we grouped plots into three categories by number of sand darters: plots with zero, one, or two or more (Table 1; see also Facey and O'Brien 2004).

In general, Eastern Sand Darter density was highest in plots with lower percentages of substrate greater than 1.9 mm in size (Figure 1). For example, half of the plots with no sand darters had 5 to 40% composition by weight of substrate sized greater than 4.1 mm, with the median and mean approximately the same, at just over 20%. In comparison, all plots with two or more sand darters had under 20% composition by weight of substrate greater than 4.1 mm, with the median and

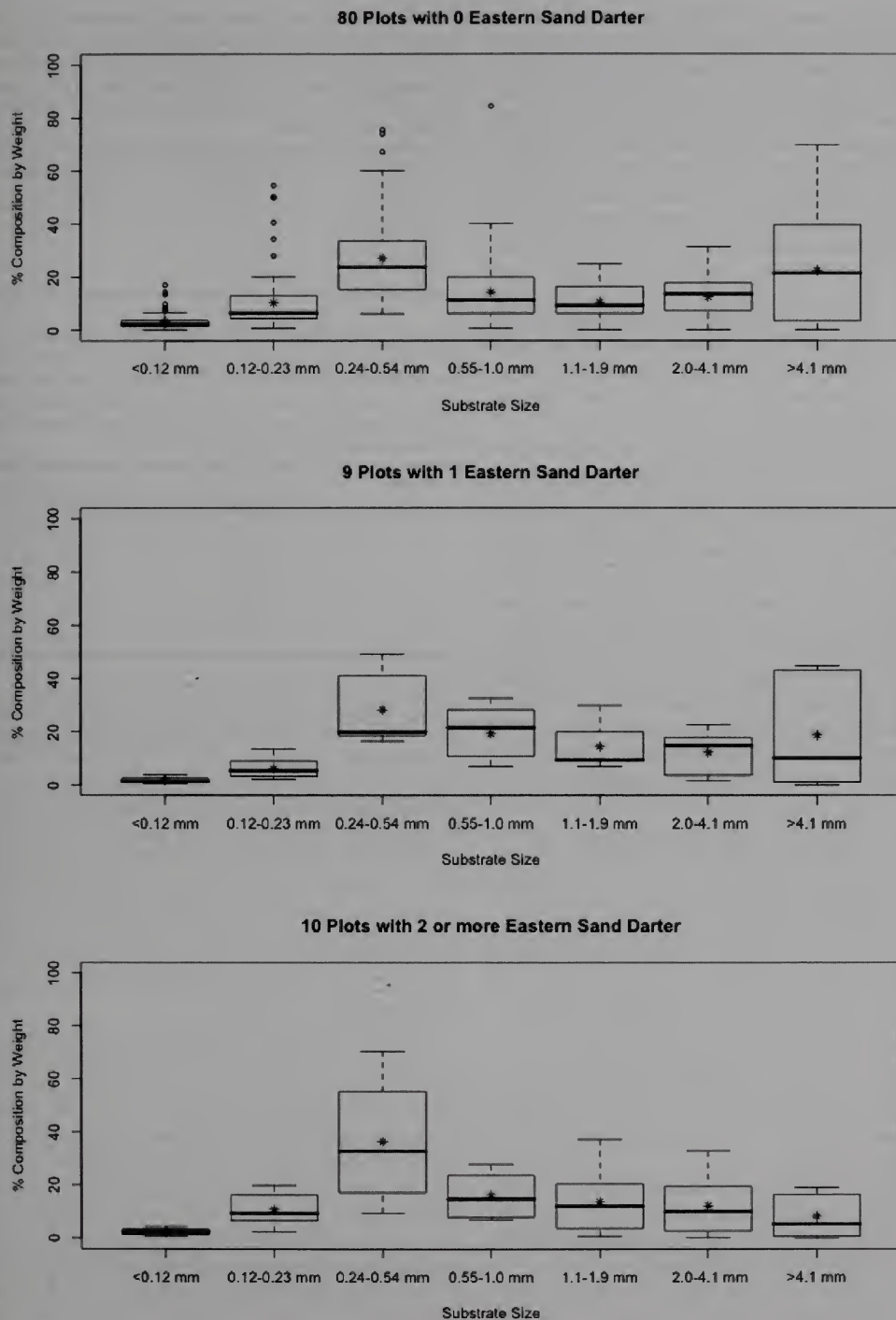


FIGURE 1. The percent composition of substrate by weight for plots with different densities of the Eastern Sand Darter (number per 30 m²) in the Poultney River (2001). The box represents the interquartile range (IQR, 50% of the data surrounding the median), vertical dashed lines represent the range of data that falls between $Q1 - 1.5 \times IQR$ and $Q3 + 1.5 \times IQR$, asterisk shows mean, black bar shows median, and circles represents outliers (those values that are greater than $Q3 + 1.5 \times IQR$).

mean at approximately 7%. Plots with no sand darters also had a much larger range for percent composition of substrate greater than 4.1 mm, with a minimum of 0% and a maximum of 70%, unlike the plots with two or more sand darters which showed a maximum under 20%. Plots with no sand darters also had less variation in percent composition of substrate 2.0-4.1 mm in size; half of these plots contained between 8 and 18% composition by weight of this size substrate. Plots with two or more sand darters had greater variability of percent composition of substrate 2.0-4.1 mm, but more plots contained below 10% composition by weight. Plots with one sand darter had less variability and smaller percent compositions of substrate sized greater than 1.9 mm than plots with no sand darters, but still had higher mean and median values than plots with two or more sand darters.

The other main difference between plots with no sand darters and those with two or more was percent composition of substrate sized 0.12-0.23 mm and 0.24-0.54 mm. Areas with a higher density of sand darters usually had a large percentage of fine to medium sized sand (0.12-0.23 mm and 0.24-0.54 mm). Half of the plots with no sand darters had between 15 and 30% of substrate 0.24-0.54 mm in size, with a mean and median below 30%. In contrast, half of the plots with two or more sand darters had 15 to 60% substrate sized 0.24-0.54 mm, with a mean and median above 30%. Similarly, more of the plots with two or more sand darters had over 10% composition of 0.12-0.23 mm substrate than did plots with none or one sand darter.

The 2002 sampling of the Winooski River yielded 112 adult Eastern Sand Darter (32-54 mm SL) from 12 of the 57 plots sampled. Forty-five plots had no sand darters, four plots contained one, three plots contained two, and each of the following densities was found in one plot: three, six, seven, 11, and 74 sand darters. Chi-square analysis showed that the sand darters did not follow a Poisson distribution throughout the sampled plots of the Winooski River (chi-square = 206.3, $P < 0.000001$, 3 df). For this chi-square analysis, we grouped the plots into five different categories based on the number of sand darters (0, 1, 2, 3, 4 or more) to ensure that the expected value for each category was above five (Table 2).

The Eastern Sand Darter in the Winooski River showed trends similar to those observed in the Poultney River. Plots with 2 or more sand darters averaged a small percentage of particles greater than 1.9 mm, with half of the plots having less than 10% composition of substrate greater than 1.9 mm. In contrast, plots with none or one sand darter averaged a large percentage of substrate greater than 4.1 mm. Plots with no sand darters had a median value of almost 50% composition of substrate greater than 4.1 mm and a mean value of 35% (Figure 2). There also seems to be a correlation between density of sand darters and percent composi-

TABLE 1. The number of plots expected and observed in the Poultney River with different densities of Eastern Sand Darter (number of fish per 30 m²). Expected values are based on the Poisson distribution, which predicts how many of the 99 plots sampled would contain the indicated number of fish if habitat selection was random.

Number of Fish	Expected number of plots	Observed number of plots
0	64.5	80
1	27.7	9
≥2	6.8	10

TABLE 2. The number of plots expected and observed in the Winooski River with different densities of Eastern Sand Darter (number of fish per 30 m²). Expected values are based on the Poisson distribution, which predicts how many of the 57 plots sampled would contain the indicated number of fish if habitat selection was random.

Number of Fish	Expected number of plots	Observed number of plots
0	7.8	45
1	15.6	4
2	15.5	3
3	10.2	1
≥4	7.9	4

tion of fine and medium sand (0.24-1.0 mm). Figure 2 shows that plots with two or more sand darters had substrate that averaged 12 to 65% 0.24-0.54 mm, with median and mean between 30 and 40%. In comparison, plots with no sand darters had more variability of composition of 0.24-0.54 mm and a much lower median value. Although plots with one sand darter did have median and mean values for substrate sized 0.24-1.0 mm, somewhat similar to plots with two or more sand darters, the plots with one sand darter averaged less substrate that was 0.24-0.54 mm and also contained much larger amounts of the coarsest sized substrate (> 4.1 mm).

Overall, the Eastern Sand Darter in both rivers occurred in areas that contained a considerable percentage of substrate particles in the 0.24-0.54 mm and 0.55-1.0 mm categories (Figures 1, 2). Our results show that for the majority of plots with sand darters, the largest percentage of substrate was 0.24-1.0 mm and the smallest percentage was usually 2.0 mm or greater. However, there were some exceptions to these trends noticed in both the Poultney and Winooski rivers. For example, in the Poultney River one plot with seven sand darters had substrate compositions more similar to plots with only one or two sand darters; however, this was only a single plot and although over 30% of the substrate was larger than 1.9 mm, the majority of the substrate in the sample was between 0.12 and 1.0 mm.

Although the field studies showed associations between substrate composition and fish distribution, they

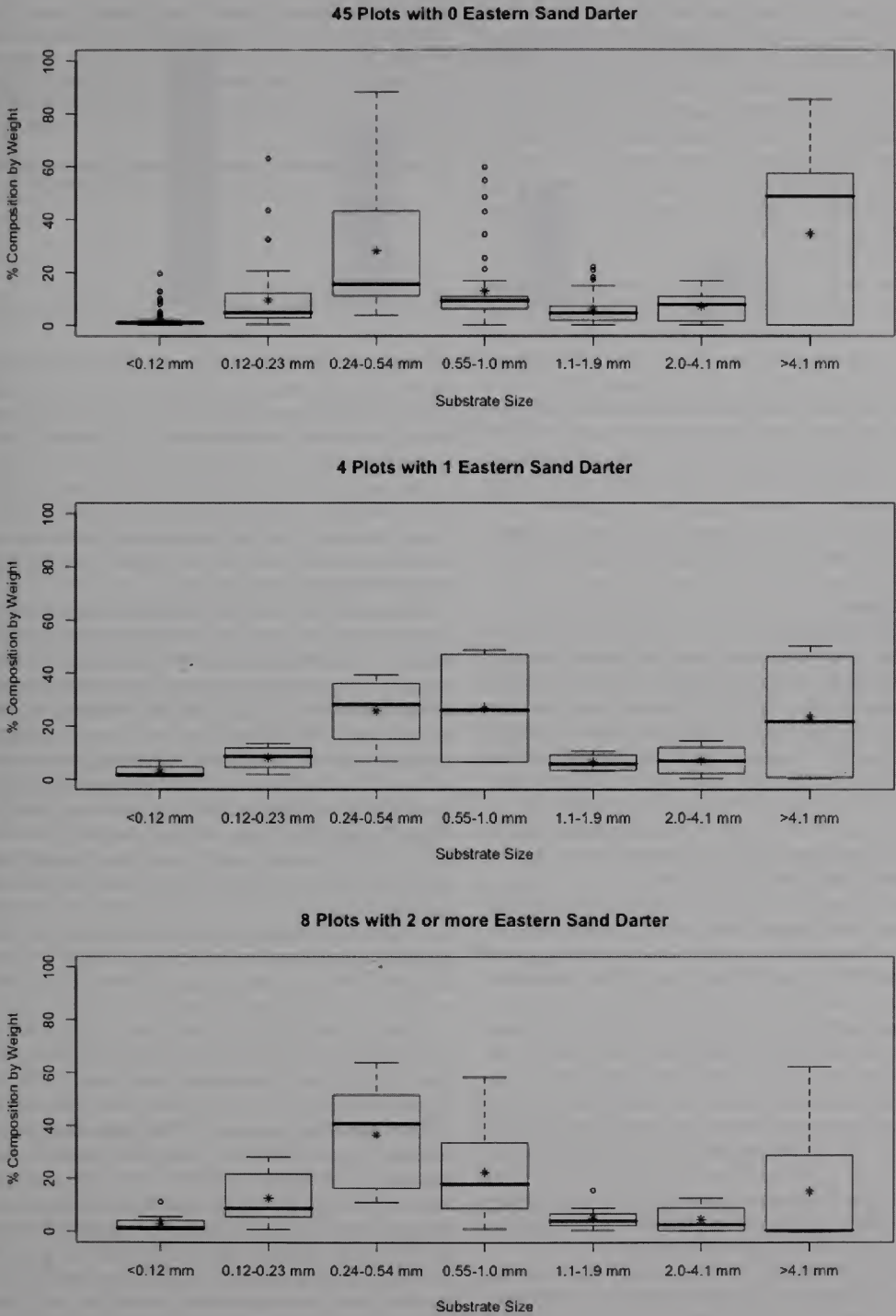


FIGURE 2. The percent composition of substrate by weight for plots with different densities of the Eastern Sand Darter (number per 30 m²) in the Winooski River (2002). The box represents the interquartile range (IQR, 50% of the data surrounding the median), vertical dashed lines represent the range of data that falls between Q1 – 1.5*IQR and Q3 + 1.5*IQR, asterisk shows mean, black bar shows median, and circles represents outliers (those values that are greater than Q3 + 1.5*IQR).

did not allow us to determine whether the Eastern Sand Darter showed a substrate preference. The laboratory study did, however, and the results suggest that sand darters preferred burrowing into the substrate rather than being on the substrate, and that they preferred substrate particles less than 1.1 mm in size. From a total of 912 observations made of 49 different fish, 790 (87%) were of burrowed fish and only 122 (13%) were of fish on the substrate. Overall, as the particle size of the substrate decreased, the tendency of the sand darters to burrow in it increased, and the fish were most often burrowed in the smallest substrate particle size available in the tank (Figure 3). Fish that were not burrowed showed a similar trend in frequency of observation on the different substrates. Throughout the study we also observed failed attempts by some of the fish to burrow into the 2.0-4.1 mm sized substrate; they then moved to another size substrate. A Chi-square analysis of the randomly selected observation periods of the Eastern Sand Darter held in aquaria showed that substrate selection was not random (Chi-square = 28.9, $P < 0.005$; $df = 3$), and suggests a strong preference for the two smallest substrate particle sizes (Table 3).

Discussion

The Eastern Sand Darter in both the Poultney and Winooski rivers inhabited areas with similar substrate characteristics; most were found in areas with a high percentage of fine- and medium-sized sand (particles 0.12 to 1.0 mm) and low percentages of substrate particles over 1.9 mm. In addition, aquarium studies showed that the Eastern Sand Darter preferred fine- to medium- sized sand when given a choice of substrates, which was consistent with the trends that we observed between substrate composition and the distribution of sand darters in the rivers.

Previous studies have indicated that the preferred habitat of the Eastern Sand Darter is areas with fine sandy substrate and shallow, slow-flowing water (Daniels 1993; Facey 1998). Many of the locations in which we found the Eastern Sand Darter fit this description. In the Winooski River, we collected 74 sand darters in one plot in a sandy area along the downstream side of an island with no measurable water velocity. The collection of so many sand darters in one plot may have been due to our sampling a drop-off along the edge of the sandbar, which allowed us to dig into the edge of the sand bar with the seine. This is not the first time that we have noticed greater success when we are able to penetrate into the sand with the seine, rather than skimming across the surface.

The only other study that we know of that has tested Eastern Sand Darter substrate choice in an artificial setting is that of Daniels (1993), who ran four trials using a 4 m \times 0.6 m tank with three substrate sections of equal area. Each section contained a different sediment particle size: sand (0.25-0.5 mm), gravel (1-2 cm), or rubble (8-15 cm). Daniels (1993) varied

TABLE 3. The number of Eastern Sand Darters observed burrowed in each of the four different sized substrates that were available in each aquarium. If the fish showed no preference, we would expect approximately equal representation among the four sediment categories. A chi-square analysis showed a highly significant preference for the smaller sediment categories ($P < 0.005$).

Sediment size (mm)	Number Observed
0.24 – 0.54	23
0.55 – 1.0	16
1.1 – 1.9	4
2.0 – 4.1	1

the depth and velocity of the water in the holding tank to simulate natural river conditions for different times of year, and reported that 84% to 90% of fish were found on the sandy substrate under all depth and velocity conditions. Less than 3% of the observations were of fish on the rubble. Our aquarium study was conducted to determine a finer resolution of substrate preference; therefore, we tested substrates in finer categories and found that 89% of the fish tested chose substrate between 0.24 and 1.0 mm.

Welsh and Perry (1998) studied the Eastern Sand Darter in pools of two rivers in West Virginia. Divers could not determine the positions of the sand darters because the fish burrowed into the sandy substrate when approached. Therefore, the locations of sand darters were determined from the shore. The microhabitats of the 10 sand darters observed were characterized by calculating the water velocity and depth, and by determining the substrate size using a grid of 25 cells, each 5 \times 5 cm, centered on the location of the fish. The results showed the mean velocity to be 0 cm/sec, the mean depth was 32.4 (\pm 6.4) cm, and the substrate size index was 2.0 (\pm 0.4), which indicates particles ranging from 0.06 to 2.0 mm. These results are consistent with ours and support our conclusions that the Eastern Sand Darter prefers substrates with small particle size.

Substrate composition is thought to be a factor affecting Eastern Sand Darter habitat utilization because of their characteristic burrowing (Drake et al. 2008), and our aquarium study supports the observations of others (see Grandmaison et al. 2004*) that sand darters tend to burrow. Therefore, changes in substrate composition could impact the fish's ability to use certain areas. Siltation has been thought to be responsible for decreases in Eastern Sand Darter populations throughout their range (Smith 1985; Daniels 1993; Holm and Mandrak 1996). Our results mainly suggested that the Eastern Sand Darter needs fine to medium grain sand and generally does not use areas with high levels of substrate greater than 1.9 mm, although our own field observations indicate that areas with a combination of fine and coarse particles may be acceptable. The Eastern Sand Darter may be unable to burrow easily into

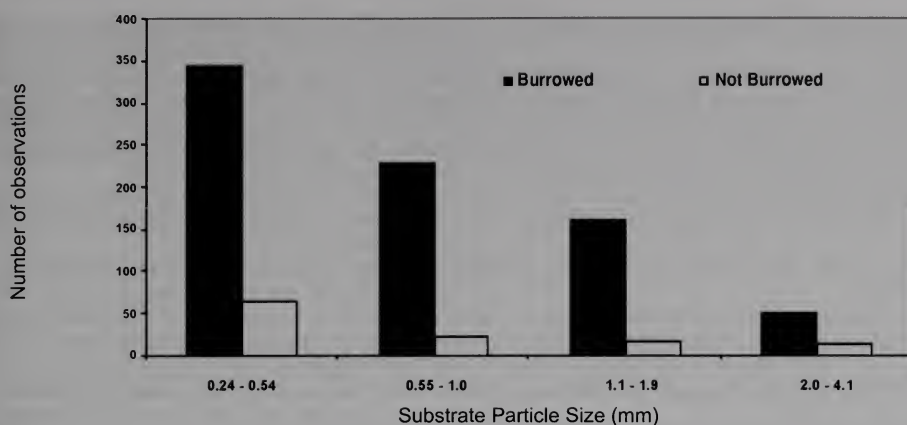


FIGURE 3. The number of times the Eastern Sand Darter was observed either burrowed into or resting on each of the different size sediments during studies in aquaria. The 790 total observations were from multiple observations of 49 different fish.

these coarse substrates, as noted during observations of fish in aquaria. Our results could not assess the impacts of mud or fine silt deposition on habitat use because large amounts of silt and mud were not characteristic of the sections of the rivers that we sampled. However, Drake et al. (2008) showed that age-0 Eastern Sand Darters grew better in areas with more sand than in areas with more silt, and argued that sand-dominated substrates would be energetically beneficial because of higher oxygen levels and greater prey availability.

Some regulations for protecting river water quality, including prevention of excess sediment input, have probably decreased silt loads and improved habitat for the Eastern Sand Darter. For example, Daniels (1993) reported that reforestation of the banks of the Mettawee River (New York) decreased the silt load and may have been responsible for the increase in the availability of sandy habitats for the Eastern Sand Darter. Daniels (1993) also mentioned that Greeley (1930) reported finding no Eastern Sand Darters during a 1929 survey of the Mettawee River and Poultney River (New York-Vermont), and that Greeley's field notes indicated that both rivers had mud bottoms. In contrast, sandy stretches of both of these rivers have supported Eastern Sand Darters since at least the 1980s (Daniels 1989, 1993; Bouton 1991*). The discovery of additional populations in several New York rivers over the last 20 years has resulted in a down-listing of the species from "Endangered" to "Threatened" in New York, and could result in further down-listing to "Special Concern" (Carlson 2008*).

The Eastern Sand Darter is quite selective of substrates utilized. Therefore, changes in substrate composition may impact the ability to utilize an area. This study confirms previous reports that the Eastern Sand Darter uses sandy habitat; however, we also provide a greater degree of resolution by identifying preferred

substrate as sand less than 1.1 mm in size. Previous reports identify habitat alteration by sedimentation as having reduced the habitat suitability for the Eastern Sand Darter throughout much of its range (e.g., Trautman 1957, 1981; Smith 1985; Daniels 1993; Holm and Mandrak 1996, Grandmaison et al. 2004*; COSEWIC 2008*). Our results suggest that the relative abundance of fine to medium sand (0.12 to 1.0 mm) and coarser substrates (> 1.9 mm) may also determine the suitability of habitat for, and abundance of, the Eastern Sand Darter.

Acknowledgments

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Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tautoga onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick

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Gilhen, J., and K. Aaboe. 2008. Winter predation by River Otter, *Lontra canadensis*, on Tautog, *Tautoga onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a review of evidence for resident relict populations of the Tautog in Nova Scotia and New Brunswick. *Canadian Field-Naturalist* 122(3): 247-252.

We report winter predation by River Otter, *Lontra canadensis*, on Tautog, *Tautoga onitis*, a southern marine fish, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia (44°46'N, 63°03'W), on 17 February 2008. We also discuss the distribution of Tautog in the western Atlantic Ocean, review Canadian records, and provide evidence that resident relict populations of this fish exist in Nova Scotia and New Brunswick.

Key Words: Winter predation, River Otter, *Lontra canadensis*, Tautog, *Tautoga onitis*, Western Arm Jeddore Harbour, distribution, western Atlantic Ocean, marine summer visitor, relict populations, Nova Scotia, New Brunswick, Canada.

The Tautog, *Tautoga onitis* (Figure 1), and Cunner, *Tautoglabrus adspersus*, are the only two wrasses (Labridae) known to occur in the marine coastal waters of Nova Scotia and New Brunswick, Canada. Both species have a laterally compressed body and rounded caudal fin. They have two series of blunt conical teeth in each jaw, the front row the largest (Figure 2), with rounded, crushing teeth at the rear of the mouth. Both species are found along rocky shoals, ledges, wharf pilings and wrecks and specialize in eating mussels and other molluscs and crustaceans.

The Tautog is readily distinguished from the Cunner in having the base of the pelvic fins located below the base of the pectoral fins (Cunner, behind the pectoral fins), the head is distinctly rounded in lateral view (Cunner, front of head pointed in lateral view) and the lower half of the operculum is without scales (Cunner, lower half of operculum with scales). The Tautog grows larger than the Cunner and is a stouter-bodied fish (Leim and Scott 1966). The dorsal fin has 16–17 spines and 10–11 soft rays (Cunner 18 spines and 9–10 soft rays), and an anal fin with 3 spines and 7–8 soft



FIGURE 1. Adult Tautog, *Tautoga onitis*, captured in a mackerel trap set off Red Bank, St. Margaret's Bay, Halifax County, Nova Scotia (44°37'30"N, 64°02'00"W), Canada, on 24 September 1973, by Eric Newton and Brian Coolen (NSM973.851.001, Negative Number N.2790)

TABLE 1. Records of Tautog, *Tautoga onitis*, from the coastal waters of Nova Scotia and New Brunswick, Canada. NSM = Nova Scotia Museum; ARC = Atlantic Reference Centre.

Specimen Number	Locality	Date	References (Collector)
NSM950	Scotts Bay, Kings County, Bay of Fundy, Nova Scotia	12 June 1902	Vladykov and MacKenzie 1935; Bigelow and Schroeder 1953; Leim and Scott 1966; Gilhen 1999
NSM 1845	Petpeswick Inlet, Halifax County, Nova Scotia	21 May 1903	Vladykov and MacKenzie 1935; Bigelow and Schroeder 1953; Leim and Scott 1966; Gilhen 1999
1 specimen	Passamaquoddy Bay, Bay of Fundy, New Brunswick	1910	Huntsman 1922; Leim and Scott 1966
1 specimen	Cranberry Head, Cumberland County, Nova Scotia	1912	Fowler 1915; Vladykov and MacKenzie 1935; Bleakney 1963; Leim and Scott 1966
1 specimen	St. Croix River at Oak Bay, Bay of Fundy, New Brunswick	1934	M'Gonigle and Smith 1936; Leim and Scott 1966
1 specimen	St. Croix River at Oak Bay, Bay of Fundy, New Brunswick	1935	M'Gonigle and Smith, 1936; Leim and Scott 1966
3 observed	Mahone Bay, Lunenburg County, Nova Scotia	2 June 1962 2 July 1962 9 September 1962	Bleakney 1963
NSM971.095.001	Off Peggys Cove, Halifax County, Nova Scotia	1 October 1971	McKay and Gilhen 1974*
ARC8600898	Dilligent River, Cumberland County, Nova Scotia	July 1973	C. Erbland (collector)
NSM973.851.001	Red Bank, St Margarets Bay, Halifax County, Nova Scotia	24 September 1973	Eric Newton and Brian Coolen (collectors)
NSM87506	Red Bank, St. Margarets Bay, Halifax County, Nova Scotia	11 July 1974	Eric Newton and Brian Coolen (collector)
ARC8601073	Passamaquoddy Bay, New Brunswick	July 1980	Scott and Scott 1988
ARC9512362	Eel Brook Lake, Yarmouth County, Nova Scotia	4 June 1981	Albert d'Entremont (collector)
NSM12676	Eel Brook Lake, Yarmouth County, Nova Scotia	17 May 1999	Albert d'Entremont (collector)
NSM88251	Western Arm Jeddore Harbour, Halifax County, Nova Scotia	17 February 2008	Kim Aaboe (collector)

rays (Cunner 3 spines and 9 soft rays), about 70 lateral line scales (Cunner about 40) [Coad et al. 1995].

On the morning of 17 February 2008 Kim Aaboe observed a River Otter, *Lontra canadensis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia (44°46'N, 63°03'W), with a Tautog it had captured as prey. KA was able to photograph the River Otter consume all but the head of this fish (Figure 3). He recovered the head and it has been added to the Nova Sco-

tia Museum of Natural History fish collection (NSM 88251). The Western Arm Jeddore Harbour site represents the ninth locality from which the Tautog has been taken in the coastal waters of New Brunswick and Nova Scotia (Table 1). Winter capture of a Tautog at Western Arm Jeddore Harbour suggests a resident population exists on the Eastern Shore of Nova Scotia, and supports Bleakney's (1963) theory that a relict population exists at nearby Petpeswick Inlet (Figure 4).



FIGURE 2. Head of Tautog, *Tautoga onitis*, from Western Arm Jeddore Harbour, Halifax County, Nova Scotia, 17 February 2008, showing blunt conical teeth (NSM.88251).

Distribution

The Cunner is a common native marine fish widespread in Atlantic Canada. Determining abundance and exact distributional status of the Tautog is complicated. Early accounts (Mitchill 1815: 359-402; Perley 1852) agree that the center of abundance for Tautog lies to the south of Cape Cod, and suggest that the species was introduced north of Cape Cod. Perley (1850) added: "northern waters seem to agree with this fish, for it has extended its range along the coasts of Massachusetts and Maine, and is now taken in St. John Harbour, New Brunswick. During the season of 1851, many Tautog were for sale in the fish market at St. John". Bigelow and Schroeder (1953) state that most authors who have written about this species have accepted Mitchill's (1815) statement that the Tautog is not native north of Cape Cod, and was introduced there shortly before 1814. However, they add: "But it seems far more likely that the anonymous writer who stated in the Gloucester Telegraph of May 5, 1860, that Tautog had been plentiful there many years before, and had merely reappeared after a period of scarcity, was correct; also that this reappearance would have taken place in any event, even if none had been liberated north of Cape Cod." We agree with the anonymous writer, and with Leim and Scott (1966), who give the distribution of Tautog as Atlantic coast of North America from slightly east

of Halifax, Nova Scotia, to South Carolina but most abundant between Cape Cod and Delaware Bay.

We also agree with Bleakney (1963) who postulated that because our coastal waters were considerably warmer a few thousand years ago, there exists the possibility of relict disjunct populations of this species in the more protected bays of Nova Scotia. At such sites summer temperatures must be warm enough to support the incubation of the floating eggs. We suggest that some individuals of southern Tautog, along with many other subtropical and tropical fishes, migrate north during the warm summer months and visit the coastal waters of Nova Scotia (Gilhen 1986) and New Brunswick. It is not known if these southern migrants contribute to the local gene pools of small northern relict populations.

The first recorded occurrence of the Tautog in the coastal waters of Nova Scotia was documented in Accession Book Number 1 by Harry Piers, Curator of the Provincial Museum of Nova Scotia (Gilhen 1999). Under Accession Number 950, Piers records a specimen 19.5 inches (49.5 cm) in length, from Scotts Bay, Kings County, Bay of Fundy, Nova Scotia, captured by T. Vardy Hill on 12 June 1902. Piers states, "New to Nova Scotia!" (Table 1).

Piers recorded a second specimen under Accession Number 1845. He purchased one of two specimens for



FIGURE 3. River Otter, *Lontra canadensis*, eating a Tautog, *Tautoga onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, on 17 February 2008.

\$0.35 in the market, both taken on 21 May 1903 in Petpeswick Inlet, Halifax County, Nova Scotia. The length to base of caudal fin of the one purchased was 13 $\frac{1}{2}$ inches (33.2 cm), and the second one was about 19 inches (48.2 cm) long. Piers stated "The woman who had them called them Black Bass".

During the summers of 1911 and 1912, D. G. Metheny collected fish at Cranberry Head, Nova Scotia, and included a Tautog in his list of 18 species (Fowler 1915). This specimen represents the third record for Nova Scotia. Vladikov and MacKenzie (1935) included the Cranberry Head record and added Yarmouth County to the locality. Bleakney (1963), however, pointed out that the only Cranberry Head in Nova Scotia is on the Bay of Fundy shore of Cumberland County.

Leim and Scott (1966) state that prior to 1957 Tautog were rarely reported from Canadian waters. They reported on three records from Passamaquoddy Bay, Bay of Fundy, New Brunswick: one about 1910 (Huntsman 1922) and two in 1934 and 1935 (M'Gonigle, and Smith 1936). Leim and Day (1959), Leim and Scott (1966), and Bleakney (1963) report that large numbers of Tautog were caught in Eel Brook Lake, a marine inlet with shallows covered in beds of blue mussel, *Mytilus* sp., in Yarmouth County, Nova Scotia. A sport fishery suddenly developed at Eel Brook Lake and about 2000 fish were caught in 1957 and about 450 were caught in 1958.

Bleakney (1963) established a fifth locality record for Tautog in Nova Scotia. On 2 July 1962 he speared an 18 $\frac{3}{4}$ inch (47.4 cm) six pound (13.2 kg) female Tautog off Crane Point, Marvin Island at Chester Basin in Mahone Bay. Broken shells of the horse mussel, *Vol-sella modiolus*, and common periwinkle, *Littorina littorea*, were in its stomach. The body cavity was extended by the greatly enlarged ovaries which contained eggs of different sizes, including a great many fully mature ones 1.0 mm in diameter. On 9 September 1962 while snorkeling over the same shoal Mr. H. Foote observed two more Tautogs, a large dark one and a smaller pale one. Bleakney reasoned this indicates the possibility of local spawning activity by a relict population of *Tautoga onitis* in the warmer inner reaches of Mahone Bay.

MacKay and Gilhen (1974*) communicated regularly with fishermen Eric Newton and Brian Coolen, who had a series of mackerel traps set in St. Margaret's Bay. They captured three Tautog, one off Peggys Cove, 1 October 1971, and two off Red Bank; the first on 24 September 1973 and second on 11 July 1974. We do not know if the Mahone Bay and St. Margaret's Bay records represent a single relict population or two separate relict populations.

The spring capture (21 May 1903) at Petpeswick Inlet and now a winter record (17 February 2008) at nearby Western Arm Jeddore Harbour strongly suggest a resident relict population of Tautog exists on the east-

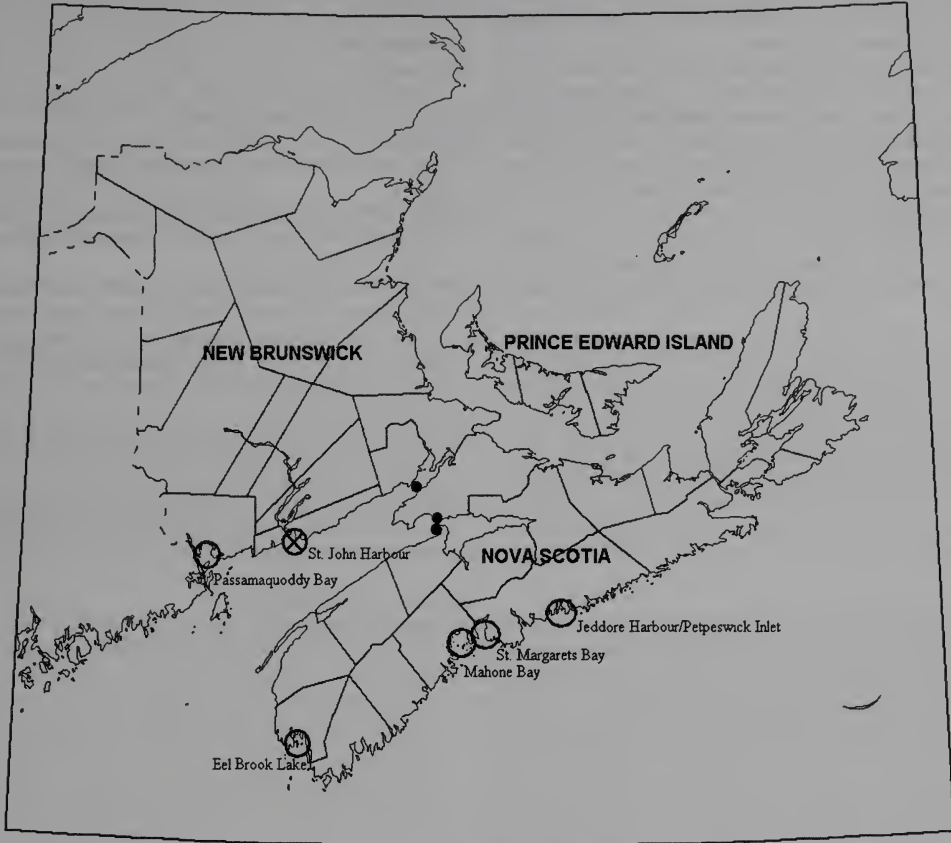


FIGURE 4. Map of maritime provinces of Canada. Closed circles represent localities where *Tautog*, *Tautoga onitis*, were captured. Open circles represent multiple captures, in areas where relict populations are believed to exist. Open circle with inside X represents a possible commercially extinct population.

ern shore of Nova Scotia. Also, the discovery of mature eggs in an adult female at Mahone Bay by Bleakney (1963) and the occurrence of small juveniles at Eel Brook Lake (Scott and Scott 1988; personal communication with Albert d'Entremont, West Pubnico) provide further evidence that spawning probably occurs in both localities on the south shore of Nova Scotia.

The number of individuals of *Tautog* in these northern relict populations must be small and this would account for the commercial extinction of the population in Saint John harbour, New Brunswick, in 1851 and the near extirpation of the population at Eel Brook Lake, Nova Scotia, following a sport fishery in 1957 and 1958.

Acknowledgments

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from the Atlantic Reference Centre, St. Andrews, New Brunswick. Ron E. Merrick, Media Services, Nova Scotia Department of Education, took the photograph in Figure 1. Albert d'Entremont, West Pubnico, Nova Scotia, has been a source of information on unusual marine fishes in Nova Scotia waters and we value his opinion on the status of *Tautog* at Eel Brook Lake. We also thank Christina McCorry, Acting Registrar, Nova Scotia Museum of Natural History, for developing the distribution map and Katherine Ogden for completing the map (Figure 4).

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Comparisons and Trends in White-tailed Deer, *Odocoileus virginianus*, Body Fat in Northeastern Minnesota, 1974-1990

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The relationships among locations of body fats have not been thoroughly examined in White-tailed Deer (*Odocoileus virginianus*). We measured bone marrow fat ($n = 2995$), back fat ($n = 1018$), kidney fat ($n = 2076$), and xiphoid fat ($n = 1246$) levels of White-tailed Deer kills from Cook and Lake counties in northeastern Minnesota during 1974-1990. For each dead deer we determined age, sex, date, and causes of mortality. All of the fat measures were correlated to varying degrees. Generally all fat measurements peaked in late autumn and subsequently began declining and reached their lowest levels in May. Fat content was negatively correlated with winter severity. Causes of mortality included predation, poaching, accidental, unknown, and auto-collisions. Predated animals had lower bone marrow (-7.42 ± 3.92) and 0.165 ± 2.30 times lower back fat and had higher amounts of kidney fat than those killed by vehicles (0.86 ± 0.43).

Key Words: White-tailed Deer, *Odocoileus virginianus*, bone marrow, kidney, mobilization, mortality, winter severity, xiphoid, Minnesota.

Physical condition is important to ungulate survival and reproduction. Poor nutritional status can often result in reduced body size, reduced antler growth, decreased reproduction, and increased mortality. Fat storage reflects the annual nutritional cycle which is why fats throughout the body are used as a general index for body condition. Wildlife managers often assess an individual's body condition as a tool for management decisions regarding populations.

In 1971 a White-tailed Deer (*Odocoileus virginianus*) reproduction study was initiated to monitor fawn production and estimate survival. Initially this was done by managers who examined vehicle-killed deer to obtain age classes, qualitative description of fat reserves, number of fetuses carried if applicable, and body weights. We also collected data on sex and cause of mortality, and measured several types of body fat (i.e., back fat, kidney fat, bone marrow fat, and xiphoid fat) to assess relative condition. The purpose of this paper is to examine fat relationships.

Several studies have correlated kidney fat with marrow fat (Finger et al. 1981; Torbit et al. 1988; Takatsuki 2000) and correlated several different bones with regards to marrow fat (Snider 1980; Ballard et al. 1981; Fuller et al. 1986; Davis et al. 1987; Husseman et al. 2003). However, few studies have examined relationships among the other types of body fat indices with bone marrow fat. Lochmiller et al. (1985) indicated that kidney fat and femoral marrow fat together made a good assessment of body condition. Finger et al. (1981) suggested that adding subcutaneous back fat to aforementioned parameters would provide a more accurate measurement of body condition. Several other studies

suggested that the most accurate evaluation of physical condition can be attained by measuring two or more indicators (Ransom 1965; Trout and Thiessen 1968; Winstanley et al. 1998), but others indicate that marrow fat may not be useful (Mech and DelGiudice 1985; Cook et al. 2001).

We examined differences in fat content of White-tailed Deer by age classes, sex, month, year, winter severity index (WSI) and causes of death. We hypothesized deer in poor body conditions (i.e., low body fat) would be targeted by predators.

Study Area

We conducted the study in Cook and Lake counties in northeastern Minnesota near Lake Superior during 1974-1990. All but a small number of deer in the region migrated to this area each winter. Elevation ranged from 180 to 700 m and the climate was cool-temperate (Hovde 1941), with snowfall averaging >150 cm during winter (Nelson and Mech 1981). The general area along Lake Superior was milder and had less snow depth than the inland area, where the weather station was located. The area where temperatures were recorded was <50 m from Lake Superior, which gets full benefit of the lake's "heat sink" effect such that the surrounding area is kept warmer in winter and cooler in summer than the inland areas. For a more detailed description of the study area, refer to Nelson and Mech (1981).

Methods

We collected data on all dead deer that were found during 1974-1990 in Cook and Lake counties. We

TABLE 1. Fat type, age class, gender, sample size, mean and fat (SD) of White-tailed Deer, northeastern Minnesota 1974-1990.

Fat	Age Class	Male (n)	Mean	(SD)	Female (n)	Mean	SD
Kidney	A	106	2.80	(1.28)	580	3.81	(1.33)
	F	471	3.02	(1.37)	479	3.21	(1.38)
	Y	167	3.01	(1.49)	273	3.51	(1.41)
Xiphoid	A	41	4.07	(4.98)	249	5.84	(5.43)
	F	224	2.94	(3.42)	198	3.16	(3.64)
	Y	82	4.79	(4.45)	128	4.74	(4.85)
Back	A	46	6.80	(10.62)	274	12.46	(12.67)
	F	246	4.89	(6.61)	214	4.74	(6.33)
	Y	93	10.24	(12.36)	145	9.68	(11.49)
Marrow	A	148	77.27	(20.64)	886	82.69	(19.63)
	F	669	71.59	(23.43)	659	73.04	(22.54)
	Y	241	75.40	(20.63)	392	77.19	(20.51)

examined each deer for sex, age (tooth eruption and replacement and by counts of dental cementum when tooth replacement was completed), and fat composition. We assigned a date of death. We classified deer as fawn (0–11.5 months), yearling (12–23.5 months), adult ≥ 24). We assumed all fawns were born on 1 June.

We removed femur bone marrow fat samples from the center of the bone and froze them until processed. We determined marrow fat conditions according to methods described by Neiland (1970). We also made several body fat measurements to compare with marrow fat contents. We estimated kidney fat based on the following criteria: (1) bare of fat, (2) slightly spotted to nearly bare of fat, (3) spotted with fat, (4) heavily spotted to nearly enveloped in fat, and (5) kidney completely enveloped in fat. We initiated the study measuring bone marrow and kidney fat; we began measuring xiphoid fat on the xiphoid process in December 1984, and back fat in August 1982. We measured xiphoid fat in mm with calipers. We measured back fat depth (mm) on the rump about 40 mm forward of the base of the tail and 20 mm to the side of the spine. Some fat measurements were not taken on all deer due to severity of vehicle impact, degree of decomposition, or because of consumption by predators or scavengers.

We classified cause of death into four categories: based upon the evidence at the site: predator, poaching, accidental, and vehicle. Winter severity was documented for each year using the Minnesota Department of Natural Resources (MDNR) index for the Grand Marais area (MDNR, unpublished data). The WSI was obtained by summing the number of days with ≥ 15 inches of snow and the number of days of -17°C , or below (MDNR, unpublished data). The temperatures and snow depths were taken at the official weather station.

Xiphoid and back fat were natural log transformed for most analyses; however, they were not transformed for the time series analysis. Kidney fat was measured on a scale so we used Spearman's rho to determine fat correlation. We used an LSMeans Con-

trast to determine if animals that died from predation or poaching had significantly different fat levels from those killed by vehicles. Fat data missing prior to when collections began for specific fat types could not be used for comparisons among the fat types, but could be utilized in analysis related to winter severity. For this analysis, in order to reduce the variation due to sample size discrepancy by mortality type, we randomly sub-sampled the 2912 vehicle collisions to 275 samples (Table 2).

We used the Autoreg procedure in SAS (SAS Institute Inc. Cary, North Carolina USA 2000) to analyze the time series analysis to determine significant explanatory variables in fat deposition and mobilization. We summarized the data with mean values of fat per month and then subjected to the time series analysis. The model included winter severity index (WSI), age class, and sex. The Autoregressive parameters were selected using the stepwise back step option.

Results

We collected 2995 samples of bone marrow, 1018 back fat samples, 2076 kidney fat samples, and 1246 xiphoid fat samples (Table 1). All of the fat measures were correlated to varying degrees. Xiphoid and back fat were the most similar in measures ($r_s = 0.87$). Kidney fat was also highly similar to marrow ($r_s = 0.6$), back ($r_s = 0.81$), and xiphoid ($r_s = 0.75$). The least correlated fats were bone marrow with xiphoid ($r_s = 0.66$) and back fat ($r_s = 0.69$). All of the fat types were negatively correlated with winter severity ($r = -0.19$ marrow; $r = -0.15$ xiphoid; $r = -0.12$ back; $r = -0.15$ kidney).

Time series model for mean bone marrow improved when age, sex, and WSI were added ($r^2 = 0.6$; with 3 parameters $r^2 = 0.63$) with 3 autocorrelated parameters. After accounting for variation in fat across years due to the autocorrelated parameters by using time series analysis, age and WSI were significant factors in bone marrow fat (age: $t_1 = 3.41$, $P < 0.001$; WSI: $t_1 = -2.11$, $P = 0.04$). As animals got older they had

TABLE 2. Mean fat and standard error by mortality type with sample sizes of White-tailed Deer, northeastern Minnesota 1974-1990.

Mortality (n)	Variable	Mean	(SE)	<i>t</i>	<i>P</i> -value
					Vehicle vs. Predation
Predation (34)	Marrow	70.12	(3.70)	-1.89	0.059
	Xiphoid	3.38	(2.10)	0.04	0.96
	Back	1.82	(1.38)	-2.16	0.035*
	Kidney	2.90	(0.34)	2.67	0.008*
					Vehicle vs. Poaching
Vehicle (275)	Marrow	76.6	(0.40)	1.66	0.096
	Xiphoid	3.39	(1.03)	0.89	0.38
	Back	4.14	(1.04)	0.58	0.56
	Kidney	3.34	(0.03)	2.01	0.045*
Poaching (20)	Marrow	69.10	(4.69)		
	Xiphoid	9.97	(2.27)		
	Back	15.64	(1.35)		
	Kidney	4.27	(0.30)		

* Significantly different from an $\alpha = 0.05$

Means and standard error for back fat and xiphoid fat are from back transformed natural log data.

more fat and during the colder months their marrow fat decreased. After accounting for variation across years, there was evidence that age and sex were significant for mean kidney fat ($r^2 = 0.82$, age: $t_1 = 2.46$, $P = 0.02$; sex: $t_1 = 1.91$, $P = 0.06$). Only 59% of the variation was explained by the time series model for mean back fat with three autocorrelated parameters. There was conclusive evidence that sex and WSI influenced mean back fat (sex: $t_1 = 3.98$, $P < 0.001$; WSI: $t_1 = -2.83$, $P = 0.04$). Back fat also was influenced by the time parameter ($t_1 = -3.28$, $P < 0.001$). The time series model explained 82% of the variation in mean xiphoid fat with three autocorrelated parameters. There was slight evidence that WSI was influential on mean xiphoid fat ($t_1 = -1.85$, $P = 0.07$). Looking at each fat over all years of the study, there is a slight decreasing trend in fat content in deer, however this was only significant for back fat (back: -0.71 ± 0.21 , $P = 0.002$; Figure 1).

Fat measures were greater for poached animals and lower for predated animals when compared with vehicle collision individuals, although this was only statistically significant for kidney fat, bone marrow and back fat (Table 2). Predated animals had lower bone marrow (-7.42 ± 3.92) and 0.165 ± 2.30 times lower back fat than those that were killed by vehicles (Figure 2). Poached animals had higher amounts of kidney fat than those killed by vehicles (0.86 ± 0.43). Due to the distribution of sample collection, we were unable to directly compare fat content of poached versus predated individuals.

Mobilization and deposition trends were similar throughout a year for all fats; therefore, we used one or two fats as examples of the trends. All deer had cyclic use of fats, decreasing fat amounts in spring (April-June) and increasing or storing over the summer and fall to the highest levels in the winter (November-

January) to again decrease in the spring. Females had more fat than males (Figure 3), and fawns and yearlings had lower amounts of body fat than adults (Figure 4). There was an inverse relationship between WSI and fat amounts (Figure 5).

Discussion

All fats were associated with each other to varying degrees. Back and xiphoid fats were highly correlated; kidney fat was also correlated with back and xiphoid fat. Bone marrow fat was largely explained by the other measures as well, though it was most different from the others, especially kidney fat. This was likely due to the asymptotic pattern rather than a strictly linear pattern that bone marrow exhibits. The trends in body condition that we detected were similar to those reported in other species comparing sex and age classes, seasonal differences, and causes of death (Franzmann and Arneson 1976; Davis et al. 1987; Spears et al. 2003).

Fat is deposited and mobilized throughout the body in a specific order (Kistner et al. 1980; Winstanley et al. 1998). Mobilization occurs in the order of subcutaneous fat, various fats throughout the abdominal cavity, and then bone marrow fat, whereas the deposition occurs in the reverse order (Harris 1945; Winstanley et al. 1998). Each fat index has limitations that can not only be due to physiological factors, biological factors, and season influences, but also can be due to collection techniques, for example, bone marrow fat is the first fat deposited and last fat reserve used by an organism; therefore, it is an excellent index for an animal in extremely poor body condition, but a poor index for animals in good condition (Mech and DelGiudice 1985; Fuller et al. 1986; Torbit et al. 1988). Another consideration is what constitutes a healthy animal in one region may be relative to other members of the popu-

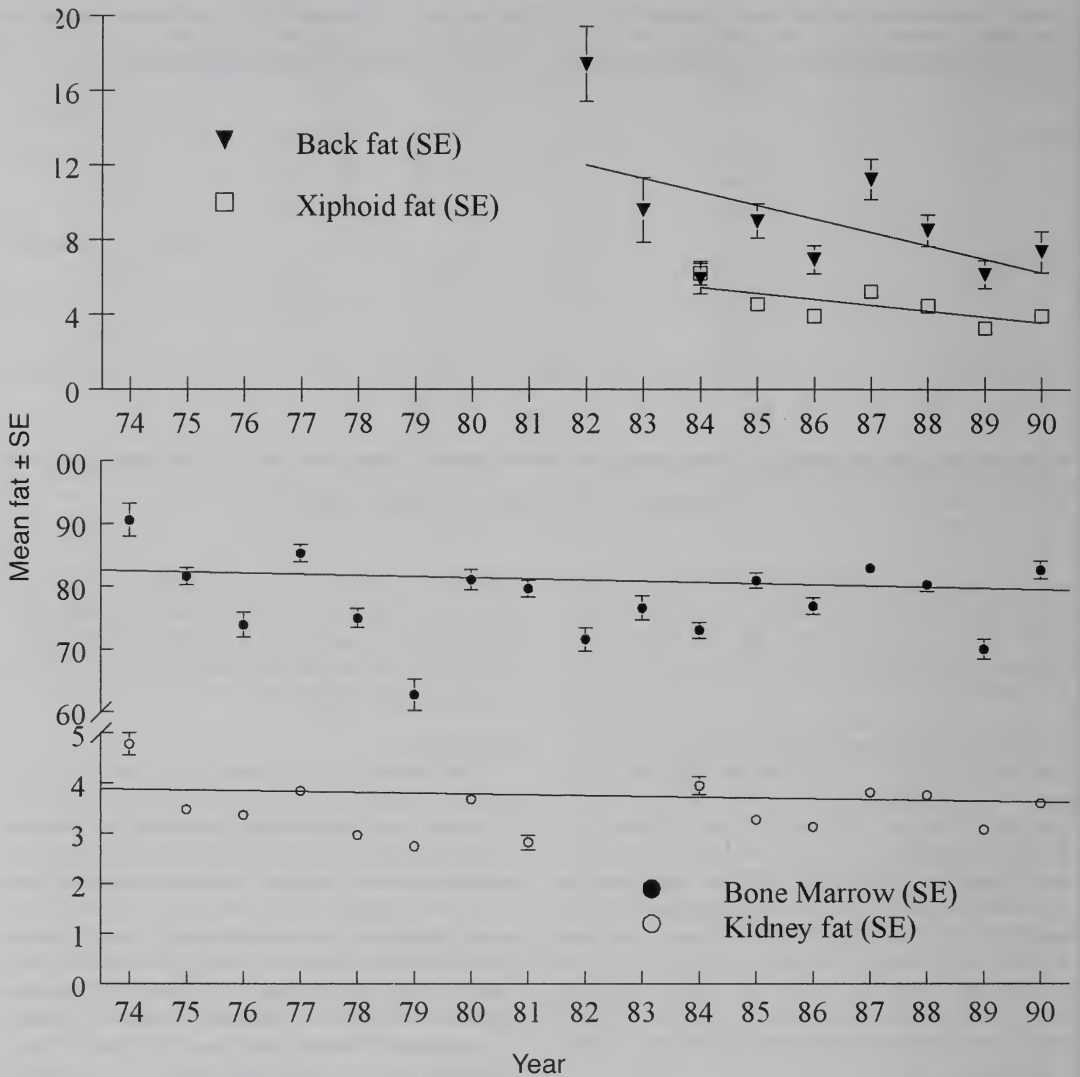


FIGURE 1. Mean fat over years of back, xiphoid, bone marrow and kidney fat from White-tailed Deer in Minnesota (1974–1990).

lation or region (Ballard 1995). Previous research indicates that marrow from other bones throughout the body may be used when the femur is not available (i.e., predation sites) and those different marrow fats are correlated to one another (Snider 1980; Ballard et al. 1981; Fuller et al. 1986; Davis et al. 1987).

Subcutaneous fats, like back fat and xiphoid fat, are deposited and mobilized in the reverse of marrow fat (Harris 1945). It is the last fat put on the body, and the first fat used. Therefore, it is only an indicator for animals which are in good condition (Harris 1945). Unlike other fats, during high stress conditions subcutaneous fats can be mobilized simultaneously from all areas of the body (Kistner et al. 1980). Back fat can be a diffi-

cult measurement to collect due to the prime location for consumption by predators and by hunter reluctance. If managers are surveying fat content at check stations in the autumn during optimal fat periods, hunters can be uncooperative by not allowing back fats to be measured due to the considerable skinning needed to obtain the measurement (Austin 1984). Recent development of ultrasound methods may alleviate the problem (Stephenson et al. 2002). However, most of our data were obtained from vehicle collisions, and therefore, back fat was usually so highly damaged from the impact that accurate measurements were impossible. Austin (1984) suggested that xiphoid fat can be a good substitute for back fat, which our data supports.

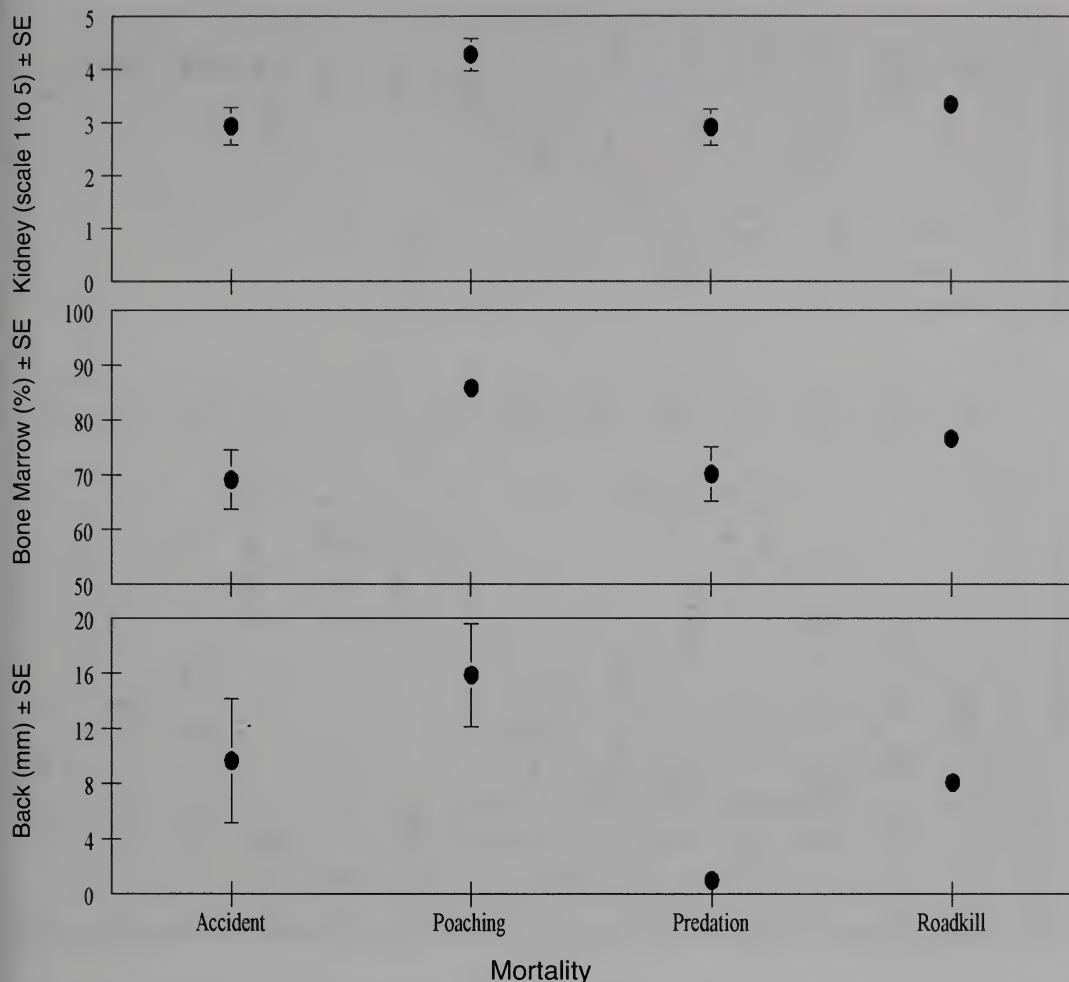


FIGURE 2. Fat measures by mortality type from kidney, back and bone marrow from White-tailed Deer in northeastern Minnesota (1974–1990).

Several studies have correlated kidney fat with marrow fat (Finger et al. 1981; Torbit et al. 1988; Takatsuki 2000) and correlated several different bones with regards to marrow fat (Snider 1980; Ballard et al. 1981; Fuller et al. 1986; Davis et al. 1987; Husseman et al. 2003). However, few studies have examined relationships among the other types of body fat indices with bone marrow fat. Lochmiller et al. (1985) indicated that kidney fat and femoral marrow fat together made a good assessment of body condition. Finger et al. (1981) suggested that adding subcutaneous back fat to aforementioned parameters would provide a more accurate measurement of body condition.

These data were not collected to examine impacts of global warming. However, they could be used in conjunction with other metadata analyses to examine possible impacts on mammalian species. There was a

slight decreasing trend of each fat amount, though it was only significant for back fat (Figure 1). This significance is primarily influenced by the data point from 1982. There are several possible explanations as to what happened in 1982. The previous winter severity was low (1981 WSI = 72); therefore, the animals had a relatively “easy” winter and a “good” amount of fat. The winter severity was high during 1982 (WSI = 142) and with the time lag the results of this severe winter would be seen after 1983; thus the decrease in fat content the following year. However, even with a lighter WSI the following years (1983 = 46; 1984 = 85; 1985 = 42), the fat content still did not increase. For all of the fats there is a slight negative trend over time. Changes in temperature can cause a change in species traits by shifting their ranges (Hughes 2000; Root et al. 2003), changing natural history traits, or

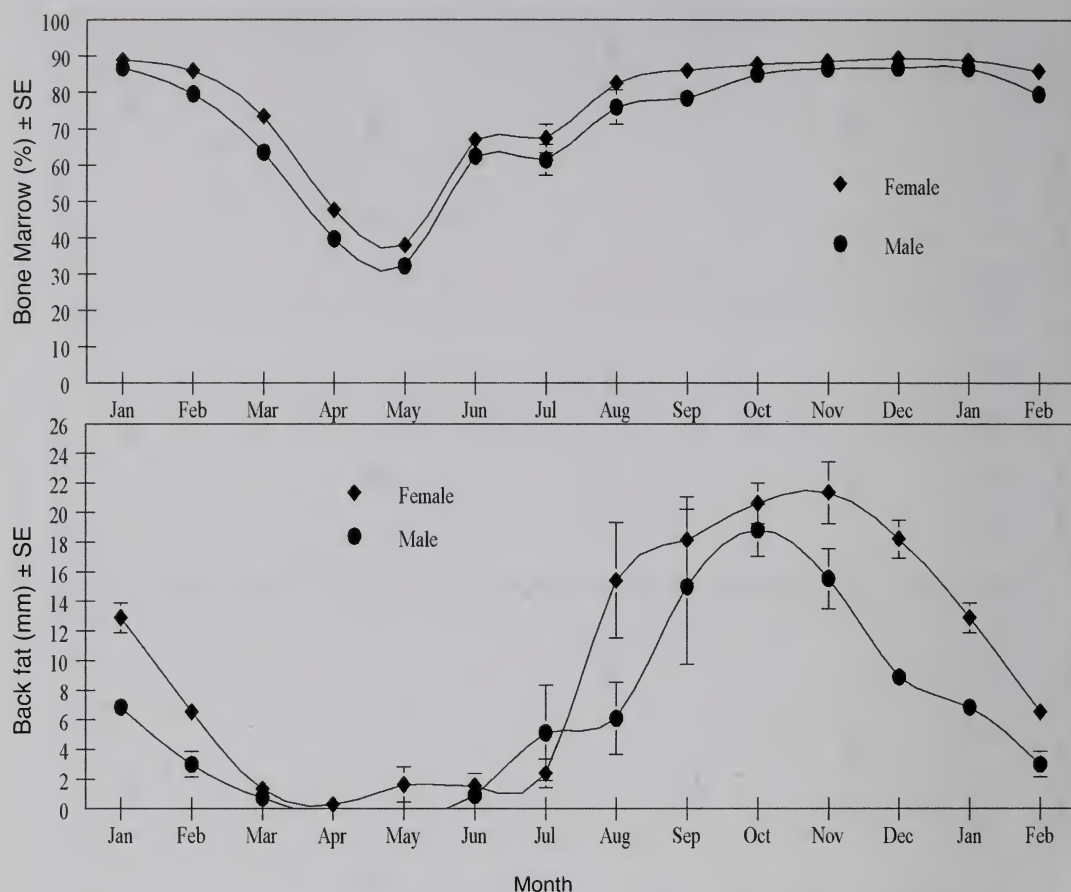


FIGURE 3. Mean bone marrow and back fat by sex averaged across months from White-tailed Deer in northeastern Minnesota (1974–1990).

changes in morphology (Barnosky et al. 2003; Root et al. 2003).

Predator-prey relationships have been discussed extensively through the years, yet what is still uncertain is the underlying mechanism of predicting predation mortality (Quinn and Cresswell 2004). One foraging theory of predators is they preferentially select the more vulnerable prey (e.g. Schaller 1972; Scheel 1993; Moore 2002; Khan et al. 2004). Vulnerability of an individual is typically defined by the age and health of the individual (Bergman et al. 2006). Determining differential selection is difficult because predation events are rarely witnessed and then it is even more complicated for biologists to determine the ultimate versus proximate cause of death. Our data suggest that the predated white-tail deer were in lower body condition than those that were randomly killed by vehicles. There is no indication that animals with low body fat preferred road travel.

Biologists will continue to debate the usefulness of traditional body fat estimates for assessing body condition at time of death (e.g., Mech and DelGiudice

1985; Watkins et al. 1991; DelGiudice et al. 1992; Mech 2007). New technologies such as ultrasonography undoubtedly will improve the determination of estimation of body condition (Smith and Lindzey 1982; Stephenson et al. 2002). However, field biologists often may not have access to new technologies and will probably continue to rely on the traditional forms of condition assessment. Our results suggest that traditional fat measurements can provide reasonable indices of body condition between sexes, among age classes, differences among years, and in relation to winter severity and causes of death. All of the fat measurements were correlated and appeared useful, but a combination of four measurements may be superior for estimating condition.

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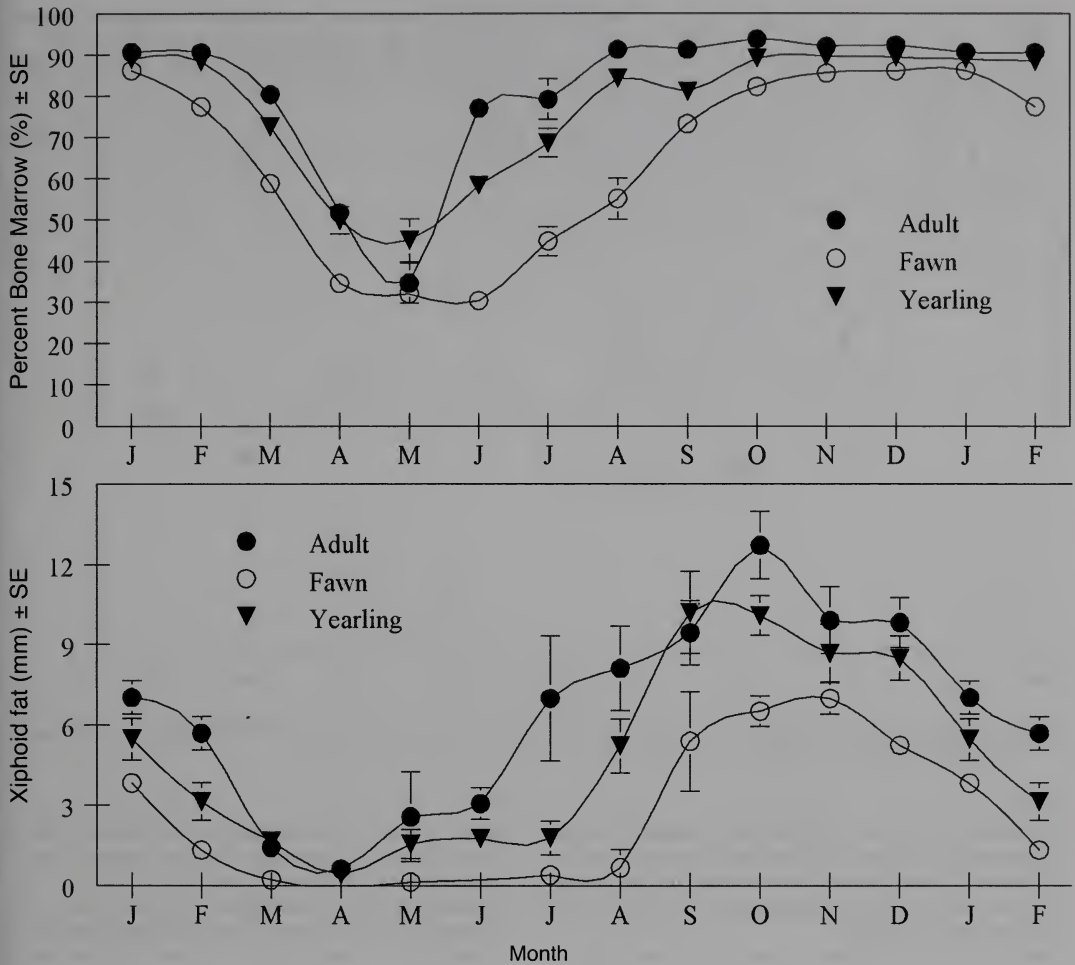


FIGURE 4. Mean bone marrow and xiphoid fat by age class averaged across months from White-tailed Deer in northeastern Minnesota (1974–1990).

pursue this and other studies that were not covered by formal research proposals. Thanks are extended to R. Fields, and T. Webb who helped collect data, and to P. Coy, who processed marrows in the early years of the study. Special thanks are due his wife, Dale, who gave up many nights, weekends, and holidays to help examine deer and collect samples in addition to putting up with having her oven used for drying marrows. Thanks to M. Borgstrom with the University of Arizona's Research Computing Support Group for statistical consults. This is Texas Tech University, College of Agricultural Sciences and Natural Resources technical publication T-9-1131.

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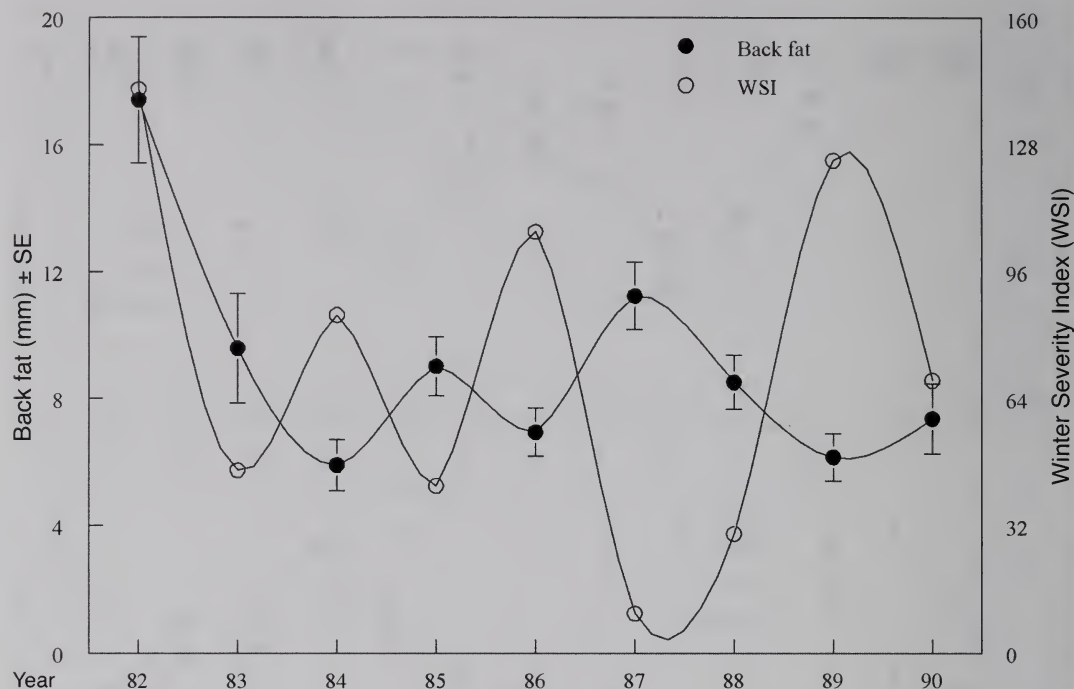


FIGURE 5. Mean back fat in comparison to winter severity indices (WSI) across years from White-tailed Deer in northeastern Minnesota (1974 – 1990).

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Notes

First Record of a Collapsed Dorsal Fin in a White-beaked Dolphin *Lagenorhynchus albirostris*, with a Gunshot Wound as a Possible Cause

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Collapsed dorsal fins are rare in odontocete cetaceans, having been reported for only a few species. We present the first known case in a White-beaked Dolphin (*Lagenorhynchus albirostris* Gray, 1846), photographed off northern Newfoundland, Canada in September 2004. The animal also had a wound on the right side of its body, anterior to the dorsal fin, with an estimated average diameter of 20–37 mm. We consider this to be a gunshot wound, most likely a 12-gauge rifled slug. The dolphin appeared to be healthy and with no movement problems, and what was apparently the same animal was seen in the same area on several dates during 2005. There is a long history of hunting small cetaceans off the Labrador coast, and a gunshot wound is the most likely cause of the wound observed. The wound may have caused the dorsal fin to collapse, as noted in other dolphin species.

Key Words: White-beaked Dolphin, *Lagenorhynchus albirostris*, collapsed dorsal fin, gunshot wound, disfigurement, Newfoundland and Labrador.

The White-beaked Dolphin (*Lagenorhynchus albirostris* Gray, 1846) is common off Newfoundland and Labrador, in eastern Canada. On 9 September 2004, one of us (DS) was leading a whale study group off St. Anthony in northern Newfoundland (51°22'N; 55°35'W) and encountered large numbers of White-beaked and Atlantic White-sided dolphins (*Lagenorhynchus acutus*) about 1.5 km offshore in approximately 60 m of water. The White-sided Dolphins were in a pod numbering thousands of individuals, with White-beaked Dolphins present in smaller groups. One White-beaked Dolphin (in a group of about 10 among a larger concentration of approximately 100) was observed with a completely collapsed dorsal fin, falling to the left side (Figure 1).

Collapsed or missing dorsal fins have been reported only rarely for any cetacean species (Baird and Gorgone 2005), and this observation represents, to our knowledge, the first report for this species. Closer observation of the photograph revealed what appeared to be a gunshot wound on the animal's right side, anterior to the dorsal fin (Figure 1). A gunshot wound would also be consistent with the small but regular harvest of dolphins that occurs off Labrador (Alling and Whitehead 1987; Lien et al. 2001). The dolphin appeared to be healthy with no locomotion problems, and the wound was not observed until the photographs were examined at a later time. An individual that appeared to be the same dolphin was also seen on at

least three separate occasions by the tour boat operator during summer 2005, but was not photographed (P. Alcock, personal communication).

Measurements of White-beaked Dolphin dorsal fin base (Hai et al. 1996) were used to estimate the size of the wound, by comparing the ratio of dorsal fin base to the diameter of the wound in the photograph. The wound diameter was estimated using the widest points (i.e., the widest diameter given the photo angle, east-west directions in Figure 1). Dorsal fin base is highly variable, ranging from 270–495 mm (Hai et al. 1996), resulting in a wide range (29–53 mm) for estimated wound diameter. Median dorsal fin base ($n = 28$) was 384 mm, translating to an estimated wound diameter of 41 mm.

Both White-beaked and White-sided dolphins (collectively known as “jumpers” or “squidhounds”) are opportunistically hunted along the Labrador coast, primarily between August and October (Alling and Whitehead 1987; Lien et al. 2001). Contacts in Labrador have informed us that dolphins are hunted using either a .303 calibre rifle or a 12 gauge rifled slug, and that slugs typically create a deep hole which gets ragged over time. The bore diameter of a 12 gauge shotgun is 18.5 mm (0.729 inches). If wounds from rifled slugs do become larger and more ragged over time, then the estimated size of the wound would be comparable with this type of injury. A colleague has observed hunted dolphins from Labrador and suggested the wound

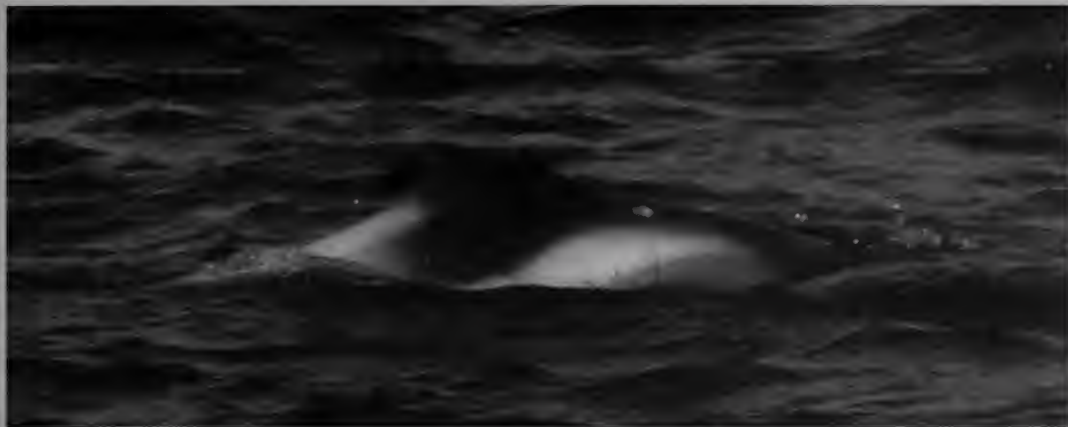


FIGURE 1. Photograph of a white-beaked dolphin (*Lagenorhynchus albirostris* Gray, 1846) with a collapsed dorsal fin taken 9 September 2004 off St. Anthony, Newfoundland (photograph by DS). Image clearly shows collapsed dorsal fin and the wound anterior to the dorsal fin.

shown here came from a rifled slug (M. Earle, personal communication).

There is always the possibility that the collapsed dorsal fin and apparent gunshot wound are not connected. However the wound may have caused infections in the cartilage, which can cause dorsal fin collapse (H. Edwards, personal communication). Gunshots have been identified as a causal factor in collapsed dorsal fins in Killer Whales (*Orcinus orca*) (Bigg et al. 1987). Other known causes (reviewed by Baird and Gorgone 2005) include intra- and inter-specific interactions, fishing gear entanglement, boat strikes, scarring from tags, and deliberate notching for identification purposes. Dorsal fin collapse appears to be rare in odontocetes, with rates in well-studied populations generally ranging from zero to <1% (Baird and Gorgone 2005). Guerrero-Ruiz et al. (2005) examined published catalogues of Killer Whales from Alaska to Mexico, and noted that only one out of > 1000 resident whales and two of > 300 transient whales had totally collapsed dorsal fins (all adult males).

Other possible causes of a circular wound include a fresh blubber biopsy dart wound or a Cookiecutter Shark (*Isistius brasiliensis*) bite. However, based on the location of the sighting and our knowledge of the local area, including current cetacean research being conducted, we believe the injury was caused by a gunshot. Biopsy darts usually make somewhat superficial wounds, and this wound appeared deeper. Cookiecutter Shark bite wounds have been observed on a number of cetacean species (Norris and Dohl 1980; Mead 1989; Debrot and Barros 1992; Gasparini and Sazima 1996). This shark is found worldwide in tropical and subtropical waters and will sometimes extend its range into higher latitudes in regions of warm currents (Jahn and Haedrich 1987; Munoz-Chapuli et al. 1998). However, it has not been found in the well-sampled Gulf Stream region (Jahn and Haedrich 1987)

and this observation is considerably north of the known range. Cookiecutter Shark bites are typically 50–80 mm in diameter (Gasparini and Sazima 1996; Lucas and Hooker 2000), but the estimated diameter of the wound here was much smaller (maximum 53 mm).

The dorsal fin is important to thermoregulation as it provides cooled blood to the female reproductive system (Rommel et al. 1993). The sex of this animal is unknown; but, if female, the collapsed dorsal fin could cause potential future reproduction problems. However, Baird and Gorgone (2005) observed two disfigured False Killer Whales (*Pseudorca crassidens*) (presumed adult females) accompanied by young calves, implying that at least some disfigured females are able to thermoregulate successfully and reproduce. The animal discussed here appeared perfectly healthy (other than the collapsed fin) and was likely the same animal seen again in 2005. There were no movement problems and it behaved no differently than other dolphins present.

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Characteristics of Porcupine, *Erethizon dorsatum*, Winter Den-sites in Living Trees in Wisconsin

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Natzke, Lori L., and Richard P. Thiel. 2008. Characteristics of Porcupine, *Erethizon dorsatum*, winter den sites in living trees in Wisconsin. *Canadian Field-Naturalist* 122(3): 264-266.

Although Porcupines (*Erethizon dorsatum*) denned in a variety of structures in Sandhill Wildlife Area, Wood County, Wisconsin, hollow living trees predominated (67 percent). Diameter at breast height of den trees was significantly greater than that of trees in the surrounding forest, and den openings in living hollow trees were nearly twice the circumference of Porcupines. Porcupines probably do not prefer certain tree species over others; rather, they select species more prone to heart rot with cavities large enough to house a Porcupine.

Key Words: Porcupine, *Erethizon dorsatum*, dens, winter dens, tree dens, den characteristics, Wisconsin.

The North American Porcupine (*Erethizon dorsatum*) has developed certain thermoregulatory and behavioral adaptations to survive the extremes of winter weather in continental North America (Clarke and Brander 1973; Dodge 1982; Oveson 1983; Roze 1987, 1989; Sweitzer 1996; DeMatteo and Harlow 1997). Although numerous studies have mentioned the importance of denning behavior among Porcupines, and a few identified the types of den structures (Roze 1987; Griesemer et al. 1996, 1998) or selection of dens in proximity to highly preferred forage trees (Zimmerling and Croft 2001), none have described physical aspects of dens utilized by Porcupines (Roze 1984, 1987; Dodge 1982 among others).

Studying porcupines in Massachusetts, Roze (1987) found that 69 percent of the dens used by Porcupines were in rock outcrops, 21 percent in living hollow trees, 6 percent in outbuildings and 5 percent were in hollow logs. Griesemer et al. (1998), who also studied denning porcupines in Massachusetts, observed that 28 percent were found in rock caves, 47 percent in cavities of living trees, 14 percent in hollow logs, and less than 3 percent in other structures. Griesemer et al. (1998) found that selection of den sites depended on topography, especially as it related to availability of rock outcrops. Roze (1987) suggested that dens offered protection from both convective and radiational heat loss, and thus aided in over-winter survival. Griesemer

TABLE 1. Differences between Porcupine den trees and tree species in random forested plots.

	Red Oak	White Oak	Black Oak	Big-toothed Aspen	White Pine
Plot %	48	13	25	12	2
% Dens	1	19	10	1	17
Mean DBH in Plots	33.0	27.4	37.2	27.9	39.2
Mean Den DBH	56.9	53.8	61.2	52.7	70.5

et al. (1998) identified protection from predation as another benefit of denning. Other studies focusing on over-winter survival strategies of Porcupines in the western United States (Sweitzer and Berger 1992; Sweitzer and Berger 1993, 1996) involved populations in which denning was rare. These authors did not mention whether adequate den structures were available and not used, or whether none existed. In this paper we describe several physical characteristics of living tree dens used by Porcupines in central Wisconsin between winters 1996-1997 and 2002-2003.

Methods

Porcupines were studied on a 206-hectare tract in the southern half of the 36 km² Sandhill Wildlife Area (SWA) located in southwest Wood County, Wisconsin between the winters of 1996-1997 and 2002-2003. SWA consists of 50 percent upland forests predominated by stands of oak (*Quercus* spp.) and aspen (*Populus* spp.) and 50 percent marshland habitats (Kubisiak et al. 2001). These forests originated following a major forest fire that swept through the region in the autumn of 1930. They were approximately 65-70 years old in autumn 2000. They have been subjected to managed timber extraction since the 1960s (Grange 1948; Kubisiak et al. 2001). Porcupines were extirpated in SWA and began recolonizing the area in the mid-1970s (Thiel, unpublished notes).

Dens were located annually between November and March by systematically searching all upland-forested habitats (953 hectares) for the presence of Porcupine snow trails and/or the presence of dens in the absence of snow. Dens were defined as cavities that were capable of totally concealing a Porcupine. Shelters were defined as cupped depressions that provided shelter from wind but left the Porcupine exposed.

Dens were classified as living hollow trees, rock outcrop, tree roots, hollow logs, culverts, or holes in the ground. An active den was defined as having fresh droppings and/or tracks at the entry. A den was considered occupied if a Porcupine was seen within or if tracks led into but not out and a Porcupine responded to tapping on the exterior of the den. The following physical characteristics were recorded at each living hollow tree den: (1) species, (2) diameter at breast height (DBH) (tree circumference 1.2 m from the ground), and (3) the greatest length and width of den entrances, measured in cm. Each den was assigned an identification number, plotted on a map, and descriptive infor-

mation was entered into a spreadsheet. Inventoried dens were visited two or more times each winter, as were newly discovered dens, to determine occupancy.

Porcupines were captured at dens and aged and sexed following methods described by Somers and Thiel (2007). Chest circumference of captured porcupines was measured immediately distal to the forelegs and compared to mathematically derived circumferences of den openings based on measurements of greatest length and width taken at right angles to one another. Data were broken down into various age-sex categories.

Timber cruises of forested habitats were conducted in March of 1997, 2000, and 2003 on randomly selected 0.0025 hectare study plots. The percent frequency of dominant tree species (after Curtis 1959) and DBH of all trees in each study plot was compared to the dataset from Porcupine dens in hollow living trees.

Results

Porcupines used sixty-three dens and seven shelters during the winter months in our study area between 1996-1997 and 2002-2003. Although shelters constituted 10 percent (7/70) of the structures used by Porcupines, they were not used consistently or for any length of time both within and between winters and they were excluded from further analysis. Amongst dens, 67 percent were living hollow trees, 9.5 percent were tree roots, 6.3 percent were in ground holes and 4.8 percent were in rock outcroppings and logs, respectively.

The DBH's of living den trees ranged from 40 cm (White Oak) to 90 cm (Black Oak). The DBH's of den trees were significantly greater than the DBH's of each of the respective tree species within the forest (t-test, $df = 4$, $P < 0.000004$). Mean den tree DBH's, by all species except Red Oak, *Quercus borealis*, (t-test, $df = 3$, $P < 0.16$), were significantly larger than the respective tree species' means within forested plots (White Oak, *Quercus alba*, t-test, $df = 13$, $P < 0.003$; White Pine, *Pinus strobus*, t-test, $df = 1$, $P < 0.02$; Black Oak, *Quercus velutina*, t-test, $df = 13$, $P < 0.001$; Big-toothed Aspen, *Populus grandidentata*, t-test, $df = 1$, $P < 0.04$) (Table 1).

Den opening circumferences averaged 99.7 cm (range 43.2-286.5 cm), and Porcupine chest girths averaged 46.2 cm (range 28.5-61.7 cm). We found no significant differences between Porcupine chest girths and the circumference of den openings among any

combination of age and sex ($R^2 = 0.23359$; ANOVA, $P < .33147$). Only three of the 42 dens in the cavities of living trees were spacious enough to house two Porcupines simultaneously.

Discussion

Porcupines in our study area selected from a variety of den structures, none of which were randomly distributed or equally available. Only 4.8 percent of the dens were rock outcroppings, yet 38 percent of study area Porcupines utilized them (Thiel, unpublished data). We report the highest incidence of living hollow trees used as dens among studies where Porcupine denning structures were mentioned (Roze 1987; Griesemer et al. 1996, 1998).

We are unaware of any documented instance of Porcupines excavating cavities in living trees. Therefore den-sites used by Porcupines in living trees are dependant upon tree species with greater incidences of rotted and hollowed cavities large enough to conceal Porcupines. In our study site White Oak, Black Oak and White Pine provided such cavities while Red Oak and big-toothed aspen generally did not (Table 1).

Zimmerling (2005) found that logs provided less insulation than other structures. If different denning structures vary in thermoregulatory benefits, then structures with better thermoregulatory properties will be occupied competitively, depending on Porcupine (and other species) densities and the relative occurrence of the better insulative structures (Somers and Thiel 2007). We found suggestive evidence of such competition between juvenile and adult Porcupines in SWA with juveniles showing a lower incidence in occupying hollow living trees than adults.

We surmise that in most managed forests in the Upper Great Lakes, where rock outcroppings are relatively rare, Porcupine use of hollow living trees will be high. In forests subject to timber extraction, hollow living trees should not be culled where Porcupine occurrence is valued.

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Diurnal Above-ground Movement in Hairy-tailed Moles, *Parascalops breweri*

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Fraser, Erin E., and Johnston F. Miller. 2008. Diurnal above-ground movement in Hairy-tailed Moles, *Parascalops breweri*. Canadian Field-Naturalist 122(3): 267.

We report the first record of Hairy-tailed Moles (*Parascalops breweri*) moving above ground during the day and suggest that the four individuals observed were young-of-the-year dispersing from their natal territories. Extreme drought conditions may also have driven these animals to move above ground.

Key Words: Hairy-tailed Moles, *Parascalops breweri*, diurnal, dispersal, above-ground, Ontario.

We observed four Hairy-tailed Moles (*Parascalops breweri*) above ground between 1 and 4 July 2007, in a residential neighbourhood north of Pinery Provincial Park, Ontario (43°17'72.4 N, 81°46'56.5 W; 43°17'72.0 N, 81°46'58.4 W; 43°17'28.5 N, 81°47'16.7 W; 43°17'37.0 N, 81°47'03.9 W). The neighbourhood is a forested community composed mainly of modified Oak Savannah habitat and with extremely sandy soil.

Three of the moles were dead on the road, and one crossed the road in front of us. *Parascalops breweri* has been recorded foraging above ground but only at night (Hamilton 1939). One of the road-killed moles appeared freshly dead and had not yet achieved *rigor mortis* in the early afternoon, suggesting it had been killed during the day. We observed the live mole crossing the road at 10:30 a.m. To our knowledge, these are the first reports of this species moving above ground during the day. No moles were observed after 4 July 2007.

We recorded the sexes, weights and lengths of two of the road-killed *P. breweri* (the posterior half of the third road-killed mole had been destroyed, making these observations impossible). One was female (weight: 43 g, length: 144 mm) and the other was male (36 g, 126 mm). We aged all three road-killed *P. breweri* based on tooth wear (Eadie 1939), and all were young-of-the-year. We suggest that they were leaving their natal nests to develop their own territories. Many small mammal species undergo natal dispersion (Sutherland et al. 2000), and young Townsend's Moles (*Scapanus townsendii*) may disperse more than 850 m, sometimes crossing paved roads in the process (Giger 1973). Little is known about the developmental biology of Ontario *P. breweri*, but juvenile individuals in New Hampshire first left their natal nests in late June (Eadie 1939). This timing roughly coincides with our observations.

We further suggest that while the majority of dispersal may be subterranean, dispersing young may find it difficult to create surface tunnels in heavily packed soil beneath roads and may choose to travel briefly above ground. The majority of subterranean activity by *P. breweri* occurs during the day (Hamilton 1939), explaining the diurnal timing of our observations.

The unusual behaviour of these moles may have been exacerbated by extreme climatic conditions. The summer of 2007 was a drought year in Ontario, with a total precipitation in June of 40.0 mm, 45.6 mm lower than average (Environment Canada 2007, results for Sarnia, Ontario, <http://www.on.ec.gc.ca/announce.cfm?ID=775&Lang=e>). Little is known about how *P. breweri* obtains water in the wild (van Zyll de Jong 1983: 156-164), but the dry conditions may have prompted the moles to search for water over a longer range.

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Egg Predation at a Golden Eagle, *Aquila chrysaetos*, Nest

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Morton, Martin L., and Maria E. Pereyra 2008. Egg predation at a Golden Eagle, *Aquila chrysaetos* nest. Canadian Field-Naturalist 122(3): 268-269.

We observed an egg being taken from a Golden Eagle nest near Atlin, British Columbia, by a Common Raven. This is apparently the first record of its kind.

Key Words: Golden Eagle, *Aquila chrysaetos*, egg predation, nest predation, Common Raven, *Corvus corax*, Say's Phoebe, *Sayornis sayi*.

Our study area was on the east-facing slope of Steamboat Mountain (59°46'N, 133°29'W), some 25 km north of Atlin, British Columbia, where we have been investigating the reproductive biology of Dusky Flycatchers (*Empidonax oberholseri*) since 1998. On the south end of the study area there is a rocky cliff about 400 m long and 80 m high that holds Golden Eagle (*Aquila chrysaetos*) nests on three separate ledges. One of the nests was active during six of the nine summers when we were present. In every nesting year, except one, one or two fledglings were produced. The failed attempt occurred when there was egg predation by Common Ravens (*Corvus corax*). Interestingly, egg predation on Golden Eagles has apparently never been reported (Kochert et al. 2002).

On 30 May 2000, our first day on the study area that year, a Golden Eagle was sitting on the same nest used in 1998 and 1999, and it was brought food at least once that day by a second Golden Eagle. At 08:50 on 5 June, while standing about 100 m north of the eagle nest with 10 × 40 binoculars in hand, we noticed that the nest was untended and that a pair of Common Ravens was approaching from the south. The ravens flew along the cliff face until one of them turned abruptly and landed on the nest. Three seconds later it flew to rejoin the other raven, did a loop in the air, and flew back onto the nest. Five seconds later it left the nest holding a large, white, unbroken egg in its mouth, the size and color conforming to eggs of Golden Eagles. Seeing this, the companion raven flew to the nest, but flew off almost immediately without carrying anything. The two ravens then flew back to the south, over the mountain's ridge, and out of view. Seven minutes later two ravens, presumably the same pair, returned along the same route. One landed at once on the eagle nest and swept its bill back and forth through the nest bottom several times before flying down to examine a crevice below the nest. Meanwhile, the other raven landed at a crevice about 15 m north of the eagle nest, where it reached in and pulled out the entire nest of a Say's

Phoebe (*Sayornis sayi*) with an adult phoebe sitting within. The phoebe flew away, its nest was dropped to the rocks below, and the ravens resumed their flight along the cliff face, eventually disappearing to the north. There was no evidence of eggs or nestlings in or near the phoebe nest when we examined it later that day, although the sitting bird itself could have been the raven's target (see Boarman and Heinrich 1999). At 09:05 a Golden Eagle appeared and circled several times above the nest site, but did not land. We were on Steamboat Mountain nearly every day until August, but no resumption of eagle nesting behavior was observed.

Golden Eagle eggs are usually protected by the incubating bird, but sometimes it will leave them unattended to hunt if the mate has not relieved it or has not brought it enough food (Collopy 1984).

Apparently, on Steamboat Mountain, a pair of foraging ravens happened by during one of these times and succeeded in robbing the nest. Common Ravens often patrol in pairs and are well-known egg predators; at times eggs can be an important part of their diet, for example, when they are preying on gull colonies (Ewins 1991, Boarman and Heinrich 1999). Due to their dexterity and large gapes, ravens can handle and carry away eggs similar in size to those of the Golden Eagle without breakage, as observed by Alvo and Blancher (2001) in a study of Common Loon (*Gavia immer*) eggs. Thus, ravens are able to seize very quickly the untended clutches of even relatively large birds, thereby avoiding potentially dangerous anti-predator encounters.

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Differential Footload of Male and Female Fisher, *Martes pennanti*, in Quebec

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We examined the mass, foot area and foot oad (mass/surface area) of Fishers (Carnivora: Mustelidae: *Martes pennanti*) captured during the 2006-2007 commercial fur season in southern Quebec, Canada. Body mass of males ($\bar{x} = 4.7 \text{ kg} \pm 0.5$, $n = 37$) was significantly larger than that of females ($\bar{x} = 2.4 \text{ kg} \pm 0.2$, $n = 40$). Similarly, the size of male feet ($\bar{x} \text{ area} = 130.5 \text{ cm}^2 \pm 10.9$, $n = 37$) was significantly larger than that of females ($\bar{x} = 95.2 \text{ cm}^2 \pm 7.6 \text{ SE}$, $n = 40$). The resulting footload of males ($36.2 \text{ g/cm}^2 \pm 6.1$, $n = 37$) was 43% larger than that of females ($25.3 \text{ g/cm}^2 \pm 2.3$, $n = 40$). These results may help explain the differential behaviour and niche partitioning in this mustelid carnivore.

Key Words: Fisher, *Martes pennanti*, footload, foot size, snow, mass, niche, Quebec.

Environmental conditions greatly affect the ecology of northern animals. In snowy environments, energetic challenges are imposed by additional locomotory costs associated with travel in snow (Crête and Larivière 2003). To overcome these costs, northern animals adapt either through behaviour or morphology. Behavioral adaptations include traveling on hard surfaces (Murray and Boutin 1991), use of snow-free areas (Sweeney and Sweeney 1984), use of tracks or trails of other animals or humans (Murray et al. 1995; Bunnell et al. 2006), reduced movements (Nellemann 1996), or broadening of diet to reduce travel needs further (Dumont et al. 2005). In contrast, morphological adaptations include longer limbs (Telfer and Kelsall 1984), reduced mass (Hodges et al. 2006), larger feet (Murray and Larivière 2002), or reduced footloading, defined as the mass per foot area ratio (Murray and Larivière 2002).

The Fisher (*Martes pennanti*) is a medium-sized mustelid that occurs throughout the forests of North America. Fishers are sexually dimorphic, with males almost twice the size of females (Powell 1993). During winter, diet of males and females differs as the smaller females are more active hunters whereas males tend to rely more intensively on scavenging ungulate carcasses (Giuliano et al. 1989). Possibly, a linkage exists between behavioural ecology and morphology, especially in northern environments where deep snow increases locomotory costs (Crête and Larivière 2003). Thus, we used footload of Fishers at the northern limit of their range to help understand this linkage.

We collected Fishers that were captured during commercial fur trapping activities. Mass and sex were recorded before pelt removal. Collected carcasses were tagged and frozen until processing. Once thawed, the four unskinned paws were removed and their outline was traced to obtain a measure of foot area. A pencil was pressed against the periphery of the digital bones as it circled the paw, thereby compressing fur and toe (Murray and Larivière 2002). The resulting prints were photographed and their area was calculated with Photoshop software (Adobe Systems Incorporated). The pixels of each foot surface area were converted to cm^2 using a known surface. Statistical comparisons between males and females were tested with a Mann-Whitney U-test.

The majority of the Fishers collected (92.0%, $n = 77$) were captured between 16 November and 31 December. The body mass of males ($\bar{x} = 4.7 \text{ kg} \pm 0.5$, $n = 37$) was significantly larger ($U < 0.001$, $P < 0.001$, $n = 37$) than that of females ($\bar{x} = 2.4 \text{ kg} \pm 0.2$, $n = 40$). Similarly, the foot area of males ($\bar{x} = 130.5 \text{ cm}^2 \pm 10.9$, $n = 37$) was significantly larger ($U = 9.00$, $P < 0.001$, $n = 77$) than that of females ($\bar{x} = 95.2 \text{ cm}^2 \pm 7.6$, $n = 40$). The resulting footload was significantly larger ($U = 13.00$, $P < 0.001$, $n = 77$) for males ($\bar{x} = 36.2 \text{ g/cm}^2 \pm 6.1$, $n = 37$) than females ($\bar{x} = 25.3 \text{ g/cm}^2 \pm 2.3$, $n = 40$).

Our study shows that although males have larger feet than females, their mass remains proportionally greater and this results in a higher footload. Interestingly, the footload of female Fisher (25.3 g/cm^2) is similar to that of the Canada Lynx (*Lynx canadensis*,

25.9 g/cm²; Murray and Boutin 1991), but much higher than that of the American Marten (*Martes americana*, 9.4 g/cm²; Krohn et al. 2003), a sister species with a much more northern distribution. Footload of male Fishers, albeit high compared to females, nonetheless is lower than that of coexisting canids such as Red Fox (*Vulpes vulpes*, 88.5 g/cm²) and Coyote (*Canis latrans*, 170.3 g/cm²; Murray and Larivière 2002) but higher than the footload of another scavenging mustelid, the Wolverine (*Gulo gulo*, 22 g/cm²; Knorre 1959). These results may help explain the differential ecology of male and female Fisher, especially in northern environments where deep snow is a constraint. However, further work should be conducted on male-female differences to better understand their behavioural ecology.

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Eastern Coyotes, *Canis latrans*, Observed Feeding on Periodical Cicadas, *Magicicada septendecim*

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Way, Jonathan G. 2008. Eastern Coyotes, *Canis latrans*, observed feeding on periodical Cicadas, *Magicicada septendecim*. Canadian Field-Naturalist 122(3): 271-272.

Eastern Coyotes (*Canis latrans*) were observed feeding on Periodical Cicadas (*Magicicada septendecim*) during their once every 17 year emergence (for three weeks) in June 2008.

Key Words: Eastern Coyote, *Canis latrans*, Periodical Cicada, *Magicicada septendecim*, predation, Massachusetts.

Coyotes (*Canis latrans*) eat a variety of prey including fruits/berries, small mammals, deer (*Odocoileus* spp.), phocids, and livestock (see Harrison and Harrison 1984; Andelt 1985; Parker 1995; Gese et al. 1996; Sacks et al. 1999; Patterson and Messier 2000; Way and Horton 2004), and feed mostly on medium to large-sized prey in northeastern North America (see Parker 1995 for a review). There is little known on the importance of insects in Coyote diets except that they appear in scats (especially seasonally) but usually in non-significant amounts, especially in terms of biomass (Nellis and Keith 1976; Litvaitis and Shaw 1980; Andelt 1985; Cypher 1993). Cypher et al. (1994), quoting Cypher (1991), noted that Coyotes consumed 13-year Cicadas (*Magicicada tredecassini*) when in abundance, indicating that insects can be an important food source when abundant. This might not be surprising, however, given that insects contribute significantly to the diets of smaller canids, such as the many species of foxes, including Bat-eared Foxes (*Otocyon megalotis*) in Africa (see Macdonald and Sillero-Zubiri 2004) and Red Foxes (*Vulpes vulpes*) in Canada (Henry 1986: 64-66). Although Eastern Coyotes are bigger than all species of foxes, it is probable that Coyotes also use insects as an important food source either seasonally or when abundant. As part of a long-term ecological study on Cape Cod, Massachusetts (Way et al. 2001, 2002, 2004; Way 2007), Eastern Coyotes were opportunistically observed foraging for Periodical Cicadas (*Magicicada septendecim*; Brood XIV, Bunker 2008*) and Cicada remains were found inside fresh scat.

I observed Cicadas first emerging during a 3-day heat wave (~32°C) starting on 8 June 2008. A couple of days later they were extremely loud in fragmented patches within my study area, within the town of Barnstable, Massachusetts (J. Way, unpublished data).

On 18 June 2008, I observed radio-collared Coyote #0801 (Way 2008a*, b*) at 0154 h under a street light on Concord Street in the village of Osterville. He walked onto the neighborhood road between two houses. On the front lawn of one of those houses he walked, sniffed, and bit at something on the ground,

then chewed it up. He did this 6 – 7 times in the 1 – 1.5 min that I observed him under the street light. This area was very close (<100 m) to a powerline right of way, a known hot spot of Cicada activity (J. Way, unpublished data). The chewing that I heard from #0801 sounded like the cracked bodies of the Cicada's exoskeletons. I monitored the Coyote until 0205. He was out of sight but his signal indicated that he was foraging in the same neighborhood, possibly on Cicadas.

On 19 June 2008, Coyote 0801 and his group (consisting of at least two or three pups and his uncollared mate) moved their rendezvous site (Way et al. 2001) > 1 km to the powerline corridor mentioned above, but > 1 km west of the 18 June sighting. On 21 June 2008, I walked the powerlines from 0542 – 0605 h and saw two pups foraging under the powerlines, around sapling trees (powerline vegetation was cleared ~5 yr before). They were doing considerable amounts of sniffing and biting at plants and I could see Cicadas jumping around them. Judging from that observation, I had no doubt that they had already learned to (and/or were taught how to) hunt for Cicadas.

During that same time frame (mid-June 2008) I also found two Coyote scats in Coyote 0801's territory that were completely full of Cicada exoskeletons. I suspect that I would have found more if I had looked more thoroughly but other field priorities at the time prevented that.

Finally, circumstantial evidence of a long-time radio-collared female Coyote (#0204: tracked from 2002 – 2008) during June 2008 indicated that her pack (two or three other adults and an unknown number of pups) may have situated their pups near a concentration of Cicadas. Her pack resided to the immediate east of 0801's pack. In my conversations with local landscapers, that area contained "an amazing number of Cicadas", where, in fact, they were so abundant the landscapers sometimes could not even mow their clients' lawns. I managed to observe #0204 in that immediate residential area (1 km from where her pups were moved to) but did not make any extensive observations partly due to the lack of streetlights in the area to observe her at night. However, her group's sudden

shift to that portion of their territory about 4 km from where she gave birth is noteworthy.

The Cicadas quieted down in early July 2008 and Coyotes resumed their normal foraging habits of traveling many kilometers per night in search of prey within their territories (Way et al. 2004). Coyote use of a periodically abundant (once every 17 years for about 3 weeks) food supply such as Cicadas might not come as a surprise, given their famous adaptability and catholic feeding habits (see Parker 1995 and sources within). Similarly, Grizzly Bears (*Ursus arctos horribilis*) feed heavily on Army Cutworm Moths (*Euxoa auxiliaris*) when seasonally abundant and gain many calories from those insects (White et al. 1998). However, it is noteworthy that Eastern Coyotes quickly learned to use this novel and rarely found food source that had not been available in that area since 1991.

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Precision of Descriptors for Percent Marrow Fat Content for White-tailed Deer, *Odocoileus virginianus*

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Based on 168 records of both verbal descriptors of White-tailed Deer (*Odocoileus virginianus*) femur-marrow fat and percentage of fat measured later, "gelatinous" served well to distinguish fat < 46% from higher percentages. "Waxy" distinguished fat > 56%.

Key Words: White-tailed Deer, *Odocoileus virginianus*, marrow fat, nutrition, body condition.

Marrow-fat content has long been used as an index of nutritional condition, especially of ungulates (Cheatum 1949). Although marrow-fat content is only a one-way test capable of indicating an animal in poor condition but not necessarily of one in good condition (Mech and DelGiudice 1985), it remains useful for indicating poor condition. The most accurate method of measuring marrow-fat content is to remove the marrow from the femur, weigh it, oven dry it, and weigh it again. The dry-weight divided by the original weight indicates the percent fat (Neiland 1970).

However, it is not always possible to collect and weigh bone marrow. For example, when one encounters a dead animal unprepared or when working in the wilderness. Then only a visual examination and verbal description are possible. There are several ways of describing marrow, usually by color and texture. The correlation between these descriptors and actual fat content, however, has not been established empirically.

Volunteer technicians described the femur marrow fat of White-tailed Deer (*Odocoileus virginianus*) and measured the fat content (Neiland 1970), and I examined the correlation between the descriptors and the actual fat measurement. Most of the deer had been killed by Wolves (*Canis lupus*), during winter, in north-eastern Minnesota from 1984 to 1990. Some 20 technicians were involved, and they examined femur marrow from 168 Deer. Descriptors used could be checked on a form and included "pink," "red," "white," "firm-waxy," "greasy," and "gelatinous."

I sorted the data file by percent marrow fat and found that the only descriptors that were consistent and reasonably well correlated with actual fat content were "gelatinous" in 15 (50%) of 31 cases with < 46% fat, and only 5 (4%) of 139 cases > 46% fat, and "firm-

waxy" used in 84 (66%) of 127 cases with > 56% fat, and only 1 (3%) of 39 cases with < 56% fat.

"Gelatinous" or "jelly" seems to be an adequate descriptor for femur-marrow fat < 46%, and "firm-waxy" for marrow fat > 56%, at least in White-tailed Deer. The percent femur-marrow fat that indicates poor body condition might vary by species, but Ballard et al. (1987) found that the mean marrow fat of starved Moose (*Alces alces*) was 52%. Thus merely being able to distinguish gelatinous marrow fat from waxy would be useful to distinguish individuals in poor condition.

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Cliff Roosting by Migrant Semipalmated Sandpipers, *Calidris pusilla*, at Farrier's Cove, Shepody Bay, New Brunswick

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An observation of Semipalmated Sandpipers roosting on a cliff face in Shepody Bay, New Brunswick, suggests changes from "traditional" roosting sites. Sandpipers may be altering their roosting patterns due to pressures from avian predators such as the recent, and successful, re-introduction of the Peregrine Falcon.

Key Words: Semipalmated Sandpiper, *Calidris pusilla*, Peregrine Falcon, *Falco peregrinus*, roosting, RAMSAR (wetland of international importance), WHSRN (Western Hemisphere Shorebird Reserve Network), Farrier's Cove, Shepody Bay, New Brunswick.

The life history of the Semipalmated Sandpiper (*Calidris pusilla*) has been well documented (Gratto-Trevor 1992). Furthermore, detailed studies describe the southerly fall migration of these birds (Morrison 1977; Elliot 1977; Harrington and Morrison 1979; Hicklin and Smith 1979; Hicklin 1981*; Hicklin and Smith 1984; Hicklin 1987) and their foraging ecology during stopover, on the macro-tidal (14 m) mudflats of the Bay of Fundy (Hicklin and Smith 1979; Boates 1980; Hicklin 1981*, 1987, 1988; Sprague 2006; Sprague et al. 2008). Consequently, in 1987, Shepody Bay, New Brunswick, was recognized as a RAMSAR site (wetland of international importance) (RAMSAR Sites of Atlantic Canada 1994*) and designated as part of the Western Hemisphere Shorebird Reserve Network (WHSRN) (Hicklin 1988).

Over the past thirty years, many studies have focused on shorebirds in Shepody Bay, including the long-term monitoring of roosting sandpipers and shorebird banding. Over this same time period, there has been an increase in ecotourism directed towards viewing the large flocks of sandpipers that roost on the beaches in Shepody Bay during high tide. For example, throughout July and August each year, 10000+ tourists visit the "traditional" roost sites at Johnson's Mills (45°50'N, 64°31'W) and Mary's Point (45°43'30"N, 64°39'30"W), New Brunswick, to observe and photograph these large flocks of birds (unpublished visitor data from The Nature Conservancy of Canada Shorebird Interpretation Centre at Johnson's Mills and the Mary's Point Shorebird Research Station at Mary's Point). These roost sites consist of exposed sand and/or cobble beaches where visibility of approaching predators would appear to be good. Roosting numbers of Semipalmated Sandpipers on these beaches have been estimated at up to 200 000 birds in a single flock (see Morrison 1977), and PH estimated a flock at 300 000 birds at Johnson's Mills in 2006. Roost site selection by

these sandpipers is influenced by tidal height since many of these shorelines can be underwater during "spring" (higher high-water) tides on some days. This lack of roosting locations, when "traditional" beaches have been inundated at the highest tide has resulted in sandpipers roosting at unusual locations such as on the secondary gravel road (Route #935) at Johnson's Mills in some years. In 1980, approximately 1500 birds were killed when a motor vehicle drove through a roosting flock (Hicklin 1981*) and on 22 August 2005, over 5000 birds were observed roosting on this same road, blocking vehicle traffic (under similar tidal conditions). Generally, shorebird roosting sites have the following characteristics: they (i) remain uncovered by the high tides; (ii) are relatively close to foraging areas; (iii) are away from areas of high disturbance; and (iv) permit unobstructed lateral vision of areas adjacent to the birds (see Elliot 1977). Within the past 5 to 10 years, use of some of these "traditional" sites by Semipalmated Sandpipers appears to be in decline as other, little used or previously unrecorded, roosting sites are frequented by significant numbers (<10 000) of birds (unpublished data). Although the true cause(s) is/are unclear, it has been speculated that the successful re-introduction of the Peregrine Falcon (*Falco peregrinus*) to eastern Canada (Amirault 2003), as well as other disturbance pressures (bird watchers and beach users), have altered the shorebirds' roosting site selection and behaviour; although sandpipers are still roosting at some sites with high numbers of avian predators (see Sprague 2006; Sprague et al. 2008). Prior to a successful re-introduction program throughout the 1980s, the last recorded Peregrine Falcon nest in Maritime Canada was reported in 1955 at Cape d'Or in Nova Scotia (Amirault 2003). By 1991, the falcons had established (or re-established) three active nest sites in the greater Shepody Bay area (Amirault 1997) and they have been active nearly every year since. These nest sites are all



FIGURE 1. Portion of a flock of 257 Semipalmated Sandpipers (*Calidris pusilla*) roosting on a vertical sandstone cliff at high tide, 23 July 2008, in Farrier's Cove, Shepody Bay, New Brunswick (Julie Dulude photo).

within the sandpipers' foraging range of the Shepody Bay mud flats' and attacks by falcons on roosting and foraging shorebirds are well-documented (Campbell 1999; Beauchamp and Ruxton 2008; Hicklin unpublished) and have become an almost daily occurrence wherever shorebirds concentrate in Shepody Bay. Conklin et al. (2008), while studying roost variations in Dunlin (*Calidris alpina*) in California, and Sprague et al. (2008) in the upper Bay of Fundy also noted the dynamic nature of roost use and roost suitability. They further noted that the movement of Dunlin amongst roosts was most strongly influenced by avian predation.

On 23 July 2008, JD and SS were conducting surveys of potentially new roosting sites for Semipalmated Sandpipers at a remote location (Farrier's Cove 45°44'N, 64°33'W) on the western tip of the Cape Maringouin peninsula at the southern boundary of Shepody Bay. Farrier's Cove consists of a 400 m long mud and cobble beach that is mostly covered during the very highest tides. The long axis of the beach, oriented NNE by SSW Magnetic, is bordered by a steep 15 m vegetated embankment while the shoulders of the cove, and adjacent headlands, consist of 15 m cliffs composed of many layers of Carboniferous sandstone.

During the observation period, high tide (12.4 m) was at 16:23, temperature was mild (17–22°C, wind NE 9 km/hr), and water very calm. On arrival (by JD and SS) at 15:23 about 3000 Semipalmated Sandpipers

were observed flying over Farrier's Cove and appeared to be attempting to roost at the northern end of the beach. By 15:53, the flock had increased to approximately 10 000 birds; although many attempts were made, no birds actually landed at the site. At 16:23 (high tide), approximately 600 sandpipers finally landed on the southern end of the beach but remained for less than ten minutes. At 16:33 a flock of 257 Semipalmated Sandpipers settled on a near-vertical sandstone cliff (~15 m) (Figure 1). At the same time, an additional 162 birds were observed roosting, in dense clusters, on large sandstone boulders which protruded above the water's surface, adjacent to the aforementioned cliff face. The shorebirds remained motionless on the cliff face for over 30 minutes and were still present when the observations ended at 17:03.

Cliff-roosting by Semipalmated Sandpipers has never before been recorded in Shepody Bay nor reported in the literature, and is uncharacteristic of what has been considered as a 'typical' roosting site (see Gratto-Trevor 1992). This suggests that this behavior is either (i) very uncommon, (ii) a new activity, or (iii) the renewal of what might have been common prior to the re-introduction of the Peregrine Falcons. Small flocks of shorebirds using remote areas and habitats such as sandstone cliffs may provide added protection against what is a comparatively new (re-introduced) avian predator (Peregrine Falcon) in the Bay of Fundy. It is also possible that the type of roost-site

selection documented here is reflective of roosting behavior when falcons were common in the Bay of Fundy in the early decades of the 20th century (before the reproductive decline attributed to organochlorine pesticide use after World War II); if so, such cliff-roosting behavior in small flocks, as documented in this paper, may once again become more common. This potential shift from large roosts on open beaches to smaller more dispersed sites, has major implications for conservation efforts which have been directed towards securing critical habitat adjacent to the 'traditional' roosting sites within Shepody Bay.

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Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars a AUD and so on. You will find these are the codes now used by financial institutions and internet currency converters. I will include an updated note for the next few issues as a reminder.

ZOOLOGY

Birds of the Kingston Region [Second Edition]

By Ron Weir. 2009. Kingston Field Naturalists, P.O. Box 831, Kingston, Ontario K7L 4X6 Canada. 611 pages. 30 CAD, Paper.

The History of the Birds of Kingston was privately printed in 1965. It was written by Helen Quilliam and ran 216 pages. This was revised in 1973 and ran 209 pages. Ron Weir's original version, called *The Birds of the Kingston Region*, was published in 1989. Weir's 2008 second edition is a full revision and is considerably expanded. There are three elements in this expansion. The first is the 28 species added to the list, bringing the total to 371. Most of these are new sightings, although a few are the result of splits like Cackling Goose and Canada Goose. The second factor in the expansion is the additional data collected in the last 18 years, amounting to over 500 000 new records. Finally, and perhaps most useful, is a series of appendices, including a Checklist of the Birds, arrival and departure dates, Christmas counts and midwinter waterfowl survey results, the last prepared by Chip Weseloh and giving a summary of the current status of the colonial water birds.

The book has an introductory section that explains how the book is organized and gives an overview of the key birding areas of the region. There is a pull-out map showing the area covered by the book and the Christmas Bird Count areas within the Kingston region.

The species text is arranged in the old Wetmore order, a great relief as this has been the sequence for many years and the one we have grown comfortable with. Each entry discusses the records since 1948, emphasizing the last 20 years. While the focus is on Kingston, there is a lot of information on each species in Ontario [and Canada], particularly for the less common birds. For example, we can read the status of the Yellow-breasted Chat in British Columbia, Alberta and southern Ontario, followed by a synopsis of its rare, but regular occurrence in Kingston.

These species accounts handle a lot of "dry" data in a constructive manner that allows for easy reading and absorption of the salient facts. The "Summary" that ends most species accounts is useful for anyone planning a birding trip to the Kingston area. For a

species like Ring-billed Gull, the categorization of "very abundant" may not be of much interest to visitors from most of North America, whereas White-eyed Vireo on the other hand is a very hard bird to find anywhere in Canada away from the Lake Erie shore. The Summary lists it as a "fairly regular rare spring visitor" suggesting this is a bird to look for in May. However, when you skip through the summary sections, the information is inconsistent for the rarer birds. The introduction list "Accidental" as "Not expected again" [this sounded severe]. So Yellow-billed Loon with one sighting is Accidental [never to be recorded again?], yet Brown Pelican with two sightings is "Casual." This seems a significant upgrade, but the designation for abundance lists "Casual" as once or twice over many years. There is also a designation for "Frequency" that includes the term "Casual" [less than once in 20 years], but the pelican occurred twice in 8 years. Purple Gallinule with two records in 15 years only ranked as accidental, yet the Black Guillemot [2 in 50 years] made "Casual." Unfortunately this confusion existed for a number of birds. Some like Fork-tailed Flycatcher are known wanderers [Accidental with 2 records] and are likely to be found again. In this case the summary is incorrect as it states only one record.

For the rare, but regular, birds like Prairie Warbler, Blue-gray Gnatcatcher, Acadian Flycatcher and even some "common" birds, like Screech Owl, that we are more likely to see near Kingston than Ottawa, we can use Appendix B [Arrival and Departure Statistics]. This well-organized and detailed table is excellent.

Overall, this is an excellent book and a worthwhile purchase for any serious birder in Ontario, northern New York and western Quebec. It is one of the most informative local guides available and is pleasant and easy to use. Not only will it travel with us this spring, but will probably encourage us to visit the Kingston hot spots more frequently.

ROY JOHN

[with input from JOHN CARTWRIGHT]

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Handbook of the Birds of the World. Volume 13. Penduline-tits to Shrikes

Edited by Josep Del Hoyo, Andrew Elliott, and David A. Christie. 2008. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 800 pages. 215 EUR, Cloth.

For the travelling birder, it can be very frustrating to realise that there is a species of bird that you may see on your next trip, but you do not have a current reference to clarify its status. For example, the Pink-browed Rosefinch – what exactly is its range? Will I be within that range? What are the characteristics that separate it from the Red-mantled Rosefinch? *Handbook of Birds of the World* has been that reference for all species it has covered to date. So it is doubly frustrating to know you are several volumes away from this precious resource. Not so the Penduline-tits to Shrikes, because they are covered in the latest volume, number 13. Can it be there are only three more volumes to the Icterids? The date set for Volume 16 is 2011, a mere two years and 28 families away. The rosefinches will be in Volume 15.

Volume 13 opens with an introductory essay on bird migration. I thought I had a good understanding of this topic. I did not. This essay might be better titled Bird Movements, because the subject is much more complex than I realised. This well-written piece takes much that I knew and much that I did not know and puts it into an organized framework. I now have a far more complete understanding of this subject. The article also points out our lack of knowledge in many areas. Doctoral students can relax; there is a host of research projects that need attention.

The main body of this volume covers 16 families covering 595 species, as follows: Penduline-tits, Long-tailed Tits, Nuthatches, Wallcreeper, Treecreepers, Rab-dornis, Sunbirds, Berrypeckers and Longbills, Painted Berrypeckers, Flowerpeckers, Pardalotes, White-eyes, Sugarbirds, Honeyeaters, Orioles and Shrikes.

Three of these families form 50% of the book; the Sunbirds, Honey-eaters and White-eyes. Of the remaining 13 families over half have fewer than 10 species. Most of the species live in Asia and Australasia.

The White-eyes are 98 species of chickadee-sized greenish to yellowish birds, most with white eye rings. This family gives me a lot of heartache. The various species are spread from Africa to Oceania, and many live on only one or, possibly two, islands. A great many of them are very similar, varying only in minute detail. For tick-listers the problems are reduced by there being only one species on each island. Within the family is the Silvereye, a greenish imp with a grey back and a broken eye ring. So the Silvereye is not a horrifying challenge to separate from the other white-eyes. My confusion comes with the 16 sub-species, some of which are confined to single islands. Why are they not separate species like the white-eyes? There is as much of a difference between these sub-species as there is between recognized species of white-eye.

Another bird that has frustrated me is the Wallcreeper, a lone species in its own family. I have looked and listened for this dove grey and carmine bird several times without success. I will have to be satisfied with the dozen lovely photographs and the equally fine artwork for now.

The honey-eaters are found in Australasia and Oceania, with several again being confined to single islands. While a few are colourful, most are Downy to Hairy woodpecker-sized, greenish or brownish birds. By contrast, the sunbirds are stunning gems. Iridescent red, blue, green and yellow are usual colours, especially among males. The beautiful yellow, shining green and blue Nile Valley Sunbird is typical and is the only species I got as a lifer while riding a donkey!

Of the smaller families the treecreepers are the most curious. This is where *Handbook of Birds of the World* comes into its own. On one page you can see illustrations of all ten treecreepers. Six of the ten are very similar and three others are quite similar. The range maps show that six are Asian and only one occurs in North America. Some have huge ranges and several have restricted ranges. One has to wonder why? Is there really only one species in all of North America?

Once again, the *Handbook of Birds of the World* authors have made appropriate decisions on which recent splits to accept. For example, the Chinese Silver-throated Tit is split from widespread Long-tailed Tit. The *Remiz* complex has been split into Eurasian, Black-headed, White-crowned and Chinese Penduline-tits. Similarly the *Sitta* complex has been split into Eurasian, Chestnut-vented, Kashmir and Przewalski's nuthatches. The Indian Golden Oriole has been split from the Eurasian. [A bird I missed last year, but hope to see this year]. These and several other splits are in keeping with the current literature.

The birding world has come to expect a consistent, high calibre from Lynx and they will not be disappointed. The *Handbook of Birds of the World* team have added another great volume with great photos, illustrations and text. It will let you compare like species such as Southern and Great Grey shrikes, [remember, though, it is a handbook not a field guide, so will not help you separate, say, the extreme plumages of Bay-backed and Long-tailed shrikes] and help you resolve distributions on a global scale. It will be particularly valuable to those who live in Asia or Australasia or who plan to travel there. Some North Americans may be disappointed to find there are only nine North American species in the 595, but only if they are not interested in the whole world of birds.

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The Return of Caribou to Ungava

By A.T. Bergerud, Stuart N. Luttich, and Lodewijk Camps.
2008. McGill-Queen's University Press, Canada. 586
pages, 49.95 CAD, Cloth.

Between the years 1958 and 1984, the George River caribou herd of the northern reaches of Labrador and Quebec (Ungava Peninsula) increased from 15 000 animals with a range of 90 000 km² to well over 600 000 animals covering a range of 750 000 km² – the largest caribou herd in the world. This is their story.

It is a unique story – a story that was hard to come by. Long-term data sets are not common in ecology. For over 20 years, the senior author, former chief biologist with Newfoundland and Labrador's Wildlife Division, and his co-authors tracked and monitored these nomads across the taiga and tundra of the sub-Arctic regions of eastern Canada.

If you wish to learn about the caribou, read this book. The book is mammoth, an *opus magnum*, chock full of data and insight into the lives of the iconic wanderer of the north. It is a rare type of work. Collection of long-term data on itinerant mammals in large wilderness settings does not come easy. Never mind the consistent institutional and financial support that is required for such research. That, in itself, is a feat. However, think of itinerant animals travelling relentlessly over thousands of square kilometers. How do you study such moving targets? For years, the authors had to find the caribou (not an easy task in those early days), capture them, and then wrestle them, measure them, sample them, collar them, and then free them not too much worse for wear. Behind these simple pages of figures and tables is an amazing wealth of field wisdom and scientific savvy.

The book attempts to answer ecology's classic question: What causes the size of animal populations to fluctuate? Each of the 16 chapters attempts to add a piece to the puzzle – historic fluctuations, forage and range, recruitment and mortality, limiting factors and the use of space, calving and migration. The authors cover it all and bring you along for the ride as you follow the roaming caribou in search of food on the arctic summer prairies, high altitude calving grounds safe from predatory wolves and bears, and relief from parasitic insects, flies and mosquitoes. Detailed as well, are the hefty changes in body and antler growth along with physical and physiological conditions as the animals calve, grow, breed and migrate.

Hundreds of figures and tables distill the years of field and lab measurements and tracking data. The long-term data reveal temporal and spatial trends and patterns that are intellectually satisfying and a beauty

to behold. The 36 colour plates at the beginning of the book are magnificent, revealing wonders of landscape and caribou few have witnessed.

This book is a wealth of information that few people are able to muster. It will therefore serve as a classic study of caribou demographics and population biology. Future caribou research will need to consider this monumental endeavor. However, the vast wealth of information is also the book's weakness. The book reads at times as simply one fact after another. The book could have benefited from a judicious editing. The reader can get lost in the prodigious detail. The writing style is more akin to what one would expect in scientific articles rather than in a work that was presumably destined for a wider audience. In addition, the insertion between chapters five and six of an unnumbered chapter on the Mushuau Innu and the caribou by a separate author appears to be an afterthought and would have been better placed as an appendix. The one appendix entitled "summer energy budgets for lactating females" also seems out of place, as if the authors wanted to squeeze in every bit of available data.

Will future generations still witness the lonesome trek of *Rangifer* across the northern reaches? As this book was published, the Government of Newfoundland and Labrador announced a \$15 million program to examine the decline in the Island caribou population from recent highs of 80 000 – 100 000 animals to current levels of 40 000 – 50 000 animals. The future of the caribou will depend largely on us. The pressures on caribou populations are no longer simply predators or parasitic insects. Human pressures are increasing across the landscape. Bergerud et al. have gifted us with an intimate gaze on a natural wonder of the world. What a tragedy if future generations had no idea about what Bergerud et al. were talking.

By definition, book reviewers are not the book's authors. That will not prevent me, however, from expressing a wish or better still, a plea – a plea for a future book, a simpler, shorter trade book that tells the story of the authors' passionate hope for the continuation of the caribou's "endless march" into the future. They have the experience. They have the passion. Maybe they have some suggestions. I hope that their story will enable future generations to study the caribou, to protect them and to care for them. Such a legacy will ensure "the return of the caribou to Ungava."

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A Photographic Guide to Seashore Life in the North Atlantic – Canada to Cape Cod

By J. D. Sept. 2008. Princeton University Press, 41 William St., Princeton, New Jersey 08540 USA 224 pages. 19.95 USD.

I have long believed that a real naturalist is interested in all life. Some of my birder friends refer to the plants that birds perch on as “green stuff.” I think that such an attitude is a sad loss because there are many wonderful, non-avian things to see on this earth. There are a lot of top quality choices for books on birds, plants and mammals. There is a more modest choice for reptiles, butterflies and dragonflies. There is not much available, however, on seashore life, so any book is welcome. Sept’s guide covers most of the common species found on rocky shores, sandy shores, mud beaches, and floating docks.

This guide covers a wide range of organisms from worms, jellies and sea anemones, through clams and crabs, to seaweeds, lichens and seashore plants. Indeed, the author portrays examples from 15 phyla. With the introductory section it is a Course 101 for shore life. Each species is illustrated with high quality, clear photographs, supported by well-written text. The author often uses the correct scientific term but adds a simple explanation in parentheses [phycoerythrin (algal red pigment)] making the text easy to follow.

This book brings back memories of many old “friends.” The Moon Jellies and Beroe’s Comb Jellies I saw floating off shore, the limpets, sea-snails and whelks in the tide pools and the Knotted Wrack cascading off the rocks. It reminded me of one of the most fascinating presentations I ever experienced. It was an explanation of the sex life of seaweed given in a swirling rock pool just behind the Peggy’s Cove lighthouse. While the author does not give this complex story *per se* there are hints in some of the algae accounts.

The book includes about 225 common species. I estimate that if you walked for an hour along a typi-

cal Nova Scotia beach you could find 20 to 30 species with ease. As the book is only 21.5 × 14 × 1.5 cm it would be easy to carry along. For the Common Periwinkle [a very tasty little beast] the photographs give a good sense of size, colour, shape and variability. These are easy to compare with the photographs of the Smooth and Rough periwinkles. Nearby you might find a beige “seaweed” made of felt. Look up Leafy Bryozoan. Push through the wrack and you will likely find a few scud, little shrimp-like critters. Keep going and you will surely find some young Rock Crabs or one of the hermit crabs. Now I have an urge to get to a beach and try poking around with this book in hand. The trouble is I am off to the Pacific next.

The author gives a brief overview of various intertidal habitats, such as sand beaches, mud flats, rocky shores and other micro-habitats. He also includes a guide to the best places in Nova Scotia, Prince Edward Island, New Brunswick, Newfoundland and Labrador, Maine, New Hampshire and Massachusetts. While the locations given are very good, almost anywhere along the coast will have a good range of species.

As much as I enjoyed this book, there is one disappointment. The author did not include any plankton. The zooplankton from the Bay of Fundy are among the most beautiful creatures on earth. Surely someone can buy one of the new digital microscopes and create a book on this neglected part of wildlife.

For \$20 this book is a great buy. Useful and useable, it will be an asset to any naturalist who wants to understand shore life in full. Better yet take a child along and get them interested – tidal pool creatures are easier to observe than flying birds or diving mammals.

A visit to Sept’s website at <http://www.septphoto.com> is also worth the effort.

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BOTANY

Glistening Carnivores: The Sticky-Leaved Insect-Eating Plants

By Stewart McPherson. 2008. Redfern Natural History Productions, Poole, Dorset, England. 392 pages, 79.99 USD, Cloth.

Stewart McPherson must love carnivorous plants. This is his sixth book dedicated to plants that catch, kill and digest insects – and even small animals, if you will. McPherson’s earlier works, all published by Redfern Natural History Productions, focused on the global diversity and ecology of the carnivorous plants. Three volumes were dedicated to the pitcher plants the largest and most spectacular of carnivorous plants.

His most recent volume highlights the sticky-leaved, insect-eating plants whose specialized leaves secrete sparkling droplets of sticky glue that trap insects; beauty to the human eye, but a drop of death to the unwary insect.

It was none other than Charles Darwin who definitively established the insectivorous or carnivorous nature of *Drosera* in his work *Insectivorous Plants* published in 1875. McPherson’s first chapter considers this relatively unknown passion of Charles Darwin. Subsequent chapters examine the botanical clas-

sification of sticky-leaved carnivorous plants, their trapping mechanisms, evolution, and known mutualistic relationships with arthropods.

The bulk of the book examines the seven known genera of sticky-leaved carnivores. Most readers may be familiar with the sundews (*Drosera*) that make up at least 188 species and that occur on every continent except Antarctica. McPherson dedicates a chapter to each of the seven genera of sticky-leaved carnivorous plants: *Byblis*, *Drosera*, *Drosophyllum*, *Ibicella*, *Pinguicula*, *Roridula* and *Triphyophyllum*. He describes each genus in terms of botanical history, plant structure, distribution and habitat, and general ecology. The final two chapters examine issues related to habitat loss and threat of extinction and to cultivation and horticulture.

McPherson's travels to the global hinterland and collaboration with botanical specialists the world over enrich this book. Complementing the text are 279

exquisite photos of various sticky-leaved species, many published for the very first time. A short but helpful glossary plus a specialized bibliography complement the text.

We are increasingly aware of the loss of Earth's biodiversity – a loss that is often irreparable and final. We seem unable to reverse the tide. However, maybe it will be books like this one that will provide a glimmer of hope. It is the progeny of an author whose passion for a marvellous and exquisite group of plants shines forth throughout these pages. If you are a devotee of carnivorous plants, this book is for you. If you just love plants, this book will carry you into an exotic world – a world that invites appreciation, care and maybe even love.

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Trees and Shrubs of Minnesota

By Welby R. Smith. 2008. State of Minnesota Department of Natural Resources and University of Minnesota Press, 111 Third Avenue South, Suite 290, Minneapolis, Minnesota 55401-2520 USA. 640 pages, 59.95 USD, Cloth.

Spectacular, comprehensive, user-friendly – this book is a must for everyone interested in trees and shrubs. Obviously it is about Minnesota but don't despair – the boreal forest and prairie regions of Saskatchewan, Manitoba and Ontario (and most other surrounding areas) have the same woody plants that occur in Minnesota. This means that the keys, descriptions, identification notes, natural history notes, and, most importantly, numerous (actually 1027) spectacular photographs will still be totally useful. This is an unbelievable buy!

The book covers all native (present prior to settlement by Europeans) and naturalized (non-native but now established and reproducing without human assistance) species of woody plants (506 trees, shrubs and vines) in the state of Minnesota. The objectives and basis for the book are outlined in a short preface. The work is intended to appeal to a broad audience. A very useful introduction follows. The maps of original vegetation, ecological provinces, climate and substrate type, are extremely valuable for all surrounding regions as well as providing an essential context for understanding distribution in the state. The book is not without surprises. A few pages in the introduction on the importance of fire in determining vegetation are unusually clear and help to provide an understanding of ecological processes. A page on forest change since settlement is also illuminating. I would like to have seen a little more about the devastating impact of alien woody plants on native ecosystems and perhaps also some warning about introduction and cultivation of non-woody native species. For more information regarding Canada see Catling (1997). Some details

on the history of the study of woody plants in the state might also have been of interest.

Following the introduction are easy to use keys to the genera. Occasional reference to an adequate glossary at the back of the book may be necessary to use this and other keys. The species are organized by their scientific names. This results in the separation of similar species such as Black Locust and Honey Locust, but of course there are compensating advantages. Where a number of species occur in the same genus a few pages of introduction and a key are provided. Coloured tabs on the edge of the pages are the same for all members of a genus. For each species there is a page of text, including a description, and notes on identification and natural history. A few things might be added to the identification notes here and there. For example, the absence of two white lines on the underside of the leaf of Canada Yew helps to distinguish it from Hemlock and Balsam Fir. Potential improvements are minor and the keys and identification aids are very good. Both state and North American distribution maps also appear on the text page. The state maps are based on herbarium specimens.

Opposite the text is a page of colour photographs of fruit, flowers, bark, leaves, and whole plants. This is often accompanied by a habit drawing by Vera Ming Wong, who also provided helpful comparable drawings of leaves of many species. The photographs are of excellent quality and in seconds will answer questions like "how do flowers of red maple differ from those of sugar maple." The book concludes with an 8-page glossary, an 8-page bibliography and an index to common and scientific names.

As soon as a comprehensive book becomes available, it results in a surge of interest and exploration in the subject area. There will be new information on

the shrubs of Minnesota, just as a result of this book. Hopefully Welby Smith will publish an update, and perhaps later a revised edition. This will provide an opportunity for some minor improvements. A few of the North American maps need minor changes, some likely too recent to have been included in this volume. For example it is not clear that *Amorpha fruticosa* is both native and introduced in southern Ontario (Catling 2006) and *Amelanchier sanguinea* occurs in Saskatchewan (Catling and Mitrow 2006). It would have been helpful if *Crataegus coccinea* and *C. scabrida* were included in the key since this increases the opportunity of their rediscovery. There is lots of space on page 583 (which is blank) for a key to all of the greenbriers (*Smilax*). Although the five other species that occur in the state are not woody, this would be helpful. Spreading invasives that are likely future arrivals to the state such as Autumn Olive (*Elaeagnus umbellata*) and Amur Honeysuckle (*Lonicera maackii*) might have been included in the keys to facilitate their future discovery in the state. Cultivated apples (*Malus*) are naturalized in Minnesota (Ownbey and Morley 1991) and probably should be in this book. The hybrid poplar, *Populus* × *jackii* Sarg. (*balsamifera* × *deltoides*) should also be discussed briefly. Smith notes that the threat of introduced White Mulberry to native Red Mulberry "does not seem great", but it does seem to be great in other regions, such as southern Ontario, where White Mulberry and hybrids occupy available space and pure Red Mulberries are increasingly scarce (personal observation). These are minor considerations for the slight improvement of a remarkable book.

What is it that makes this book so comprehensive? The author reads the scientific literature and communicates with world experts. It will be of interest to Canadians that he sought the help of prominent Canadian scientists George Argus, world expert on willows, and James Phipps, world expert on hawthorns. The current, sensible and accurate treatments of complex groups such as serviceberries (*Amelanchier*), hawthorns (*Crataegus*), raspberries and blackberries (*Rubus*) and willows (*Salix*), make this book especially valuable. *Rubus* expert Mark P. Widrechner is the senior author of the treatment of *Rubus* which is based largely on 300 recently collected herbarium specimens.

This is not the first book on the woody plants of Minnesota published by the University of Minnesota Press. Possibly the first was *Minnesota Trees and Shrubs* (Clements et al. 1912). Rosendahl and Butters (1929) is a revision of the same book with much of the same text and illustrations. It was later expanded

and revised to cover the upper Midwest (Rosendahl 1955, second printing in 1963), but Smith's book is the biggest improvement yet and it is quite a different book. Other specialized regional books on woody plants that are available now for Ontario and the prairie provinces include Lamont (1980), Soper and Heimburger (1982), Stephenson (1973), Laurialt (1992), Farrar (1995), and Kershaw (2001). Although all of these books on woody plants are very useful, they are out of date and incomplete. As a result, Smith's book is very important.

Trees and Shrubs of Minnesota will serve as a valuable reference to a very broad audience ranging from an average gardener to teachers and specialized plant taxonomists. It is highly recommended. For another outstanding book by this author, see a review of *The Orchids of Minnesota* in *The Canadian Field-Naturalist* 108: 263-264.

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ENVIRONMENT

Major Invasive Organisms in Agriculture of China

By Liu Guoliang, Fu Weidong and Liu Kun. 2008. Science Press, 16, Dong-huang-cheng-gen North Street, Beijing 100717, China. 409 pages. 86.00 CNY.

The alien or non-indigenous organisms are those occurring in the areas outside their native range. They may be moved to the new area intentionally, accidentally or move on its own. Many alien organisms are highly beneficial in the area of introduction. However, they can become problematic if they become agricultural pests or invaders. The invasive organisms are the alien organisms that have naturalized or permanently established and self-sustained in non-native areas. The invasive organisms often quickly flourish and dominate in their adopted homes or their new surroundings, and reach higher densities than in the native homes due to a lack of suppression from natural enemies. They may out-compete the native plants or animals in the new area, threaten biological diversity of the new habitats (worldwide, according to the IUCN, the threat to biodiversity from invasive alien species is second only to that posed by habitat destruction), hinder recreational activities, clog waterways, disrupt, damage or degrade the natural ecosystems by displacing the native species, hybridizing with native populations, altering the ecological factors, transmitting diseases and parasites not found in native species, and so on. The damages caused by invasive organisms in their adopted homes are sometimes serious or even disastrous to horticulture, agriculture, fishery, forestry and so on. They can also adversely affect society by causing health problems to humans, causing economic damage or increasing the costs of upkeep such as on railway lines, roads and shorelines. Sometimes, their full effects often are unable to be detected until they become difficult to control.

Agriculture is the most important economic sector in China, with its output being the largest in the world, employing over 300 million farmers and supporting over 20% of the world's population. From this point, the maintenance of the stability and security of agriculture in China is of utmost importance. However, with the fast development of globalization and international trade, many invasive organisms have been increasingly imposing threats to the agriculture of China. IUCN has listed 100 species of most threatening invasive organisms in the world, among which more than 50 species have invaded China. According to the preliminary statistics, more than 400 invasive

species in China have caused more than 100 billion CNY losses each year. Obviously, invasive organisms have become a new intractable problem in the Chinese agricultural ecosystem. The more information about the invasive organisms is understood, the more efficient countermeasures can be taken when dealing with the problem. The book *Major Invasive Organisms in Agriculture of China* focuses on the major invasive organisms that affect agricultural production and human health in China. Its timely publication meets current and urgent demands. The book reflects the conscious responsibility of Chinese scientists in raising public awareness and suggesting effective countermeasures for controlling the invasive organisms. It is a systematic summation of the studies of the authors in the related field. As well, it collected and analysed other abundant information in this field at home and abroad.

Introduced are 85 species of invasive organisms that have caused serious damage or would potentially threaten the agricultural production and ecological safety of China. The book generally consists of three parts. These parts introduce the origin, distribution, main morphological characteristics for identification, main biological and ecological characteristics, the ways of invasion and dispersal, and prevention and control measures, the main characteristics of damage or symptoms of 30 malignant species of alien invasive plants and animals, as well as 25 main species of alien invasive pathogen, respectively. The leading invasive species threats to Chinese agriculture are insects, weeds, and pathogens. The best method for combating the effects of these invasive organisms is to prevent their initial entry into China. But, once they have entered, aggressive strategies are needed to control their establishment and spread.

The book is well written with few errors and strong readability. It may be used as a good reference by persons who engage in agricultural or biological research, education, production and management, or other persons who are interested in these fields.

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Lost Worlds of the Guiana Highlands

By S. McPherson. 2008. Redfern Natural History Productions, Poole, Dorset, England, UK, 385 pages, 29.99 GBP, Cloth.

The table-topped mountains, or tepuis, of the ancient Guiana Shield of northern South America first came to prominence with the novel *The Lost World* written by Sir Arthur Conan Doyle in 1912. In this story, contemporary humans were warring with ape-like creatures in the midst of dinosaurs on top of flat mountains surrounded by vertical cliffs. Apparently, the idea came after Doyle heard a lecture in London on the first ascent of Mount Roraima, which now forms the tripartite border with Brazil, Guyana and Venezuela, by Everard Ferdinand Im Thurn in 1894. Besides being an explorer, naturalist and later diplomat, Im Thurn was curator of the British Guiana museum and his climb to the top of Roraima at almost 3 000 metres elevation was to primarily collect plants for Kew Gardens in England. Not only did he bring back new species to science, but also many new genera found only on tepuis, which may have been the inspiration for the unexpected findings in *The Lost World*.

This intrigue and fascination is continued and aptly conveyed by the *Lost Worlds of the Guiana Highlands* by Stewart McPherson. It is well written and liberally supported by spectacular colour photographs of magnificent landscapes that are unique to this region of the world. After a brief introduction to the Guianas, the layout of the book, and an explanation of terms used in the text, the author starts off with a bang by presenting 24 consecutive photo spreads of jaw-dropping images of tepuis. Next, he settles you in with a lesson on the geological history that gave rise to the unusual geographic features found in this area. One of the longer chapters covers the human history of and man's interaction with the Guiana Highlands, starting with the indigenous Amerindians living in the shadows of the mountains to the European colonists looking for the imaginary golden city of Eldorado. My only criticism of this book is the overuse of lengthy quotations of passages from the published journals of the early explorers. Granted, it would be very difficult to get and read many of these old publications, but I was looking for a modern interpretation and distillation of the sometimes difficult-to-follow Old English grammar.

My favourite chapter is titled "Some Strange Country of Nightmares", which is based on a quote by Im Thurn on his first impressions of the features on the summit of Roraima that are seemingly from another world. The images of eroded and sculpted rock are

enough to make me go there myself to check it out. The next chapter discusses the evolutionary processes that result in the speciation of the unique tepui flora and fauna, and the ecological processes that maintain this biodiversity. Almost a quarter of the book is a chapter devoted to describing the unusual organisms that live in this environment "above the clouds". More to the strength and interest of the author, there is a preponderance of botanical discussion with in-depth detail on the bizarre lifestyle of the carnivorous plants. Animals get short shrift but some of the tops of the higher tepuis are probably essentially devoid of vertebrates. However, surprisingly, there is an endemic rat (*Podoxymys roraimae*) found only on the summit of Mount Roraima and so different that it belongs in its own genus.

The last chapter examines the future prospects of the Guiana Highlands in terms of exploration, the indigenous people living in the area, and conservation from a regional perspective. Although the scenery and landscape are beautiful, the plateaus are in the remote and sparsely-inhabited interior of the Guianas. However, with the construction of roads and associated influx of settlers from the populated coast, particularly in Venezuela, this relatively unknown tropical paradise will undoubtedly experience substantial change in the near future. Most mountain tops have been unexplored and one recent discovery was an extensive subterranean cave system, which may entice the breed of hearty adventure seekers. A city of gold was never found but mining still occurs throughout the area, albeit primarily on a small scale. Nonetheless, there are ecological impacts with altering of the landscape and poisoning of the rivers with the use of mercury in the gold extraction process. The challenges will make it difficult to maintain the uniqueness of the area but the Amerindian communities seem cognizant of their task to preserve the ecosystem for future generations.

Notwithstanding a few errors, such as page references in the index are not in numerical order and inaccuracies like the caption in Figure 10 which actually should be the view of the prow of Mount Roraima towards the east, the book is well worth the read. It will be of interest to people searching for something off the beaten track.

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Culturing Wilderness in Jasper National Park: Studies in Two Centuries of Human History in the Upper Athabasca River Watershed

Edited by I. MacLaren 2007. University of Alberta Press, Edmonton, Alberta. 356 pages. 45.00 CAD Paper.

I was captivated by this book, starting with the cover – I’ve stood on that same spot on Tonquin Hill looking out over Amethyst Lakes and The Ramparts, near the Continental Divide in Jasper National Park (JNP). I patrolled Tonquin Valley as a park warden in 1986. This book would have been very useful when I worked as a park naturalist in JNP in the early 1980s, interpreting the history of the park to the public. The most recent historical treatise at that time was a limited circulation monograph by Brenda Gainer, which I still have, full of yellow highlights and annotations in the margins.

It’s hard to define the audience for this book. It is published by an academic press and has nearly 700 footnotes. There is lots of interesting information in the footnotes, but it is difficult to switch back-and-forth from the text to them. Incorporating more of the information into the text would have made it more accessible, but just the same, it flows smoothly enough to be of interest to a dedicated general interest reader.

Editor Ian MacLaren compiled essays by a number of authors that address the main history of the area now known as JNP – or at least that area encompassed by the Athabasca Valley. It is a major part of the park, and certainly the main east-west corridor through the mountains that people travelled, but it is much more influenced by humans than the rest of the park. The premise seems to be to challenge what the authors consider the dominant view of the park as “wilderness” – yet there are vast areas of the park that are wilderness away from the Athabasca Valley.

But the authors have done an admirable job of chronicling the major epochs of the history of the Athabasca Valley. Michael Payne starts with the fur trade in the early 1800s, which sets the stage for the claim that the valley was far from being wilderness by the time it was established as a national park in 1907 (that chapter alone has 99 footnotes). This is followed by Ian MacLaren’s examination of the travels of Henry James Warre and Paul Kane, who captured the essence of the fur trade era using paint and pencil. I recall using a Warre sketch as a cover illustration on a short historical chronology that I compiled for Parks Canada and the Jasper-Yellowhead Historical Society in the early 1980s. While many of their paintings were romanticised, both artists brought to life the triumphs and travails of the times. While there is a “partial typonymy” at the beginning of the book, a map of Western Canada showing some of the fur trading posts and routes, as well as the travels of Thompson, Warre and Kane, would have served readers well.

The third chapter, by Peter J. Murphy, traces the political manoeuvrings to establish the boundaries of

the national park, and the forest reserve that pre-dated the park. Few Canadians know that the Rocky Mountain national parks were once much larger than today, but that federal-provincial struggles meant that areas that had industrial potential (e.g., coal mining, forestry, hydro electric) were eventually excised from park protection. Fold-out maps help the reader to follow the convoluted boundary changes. The parks were initially established as forest reserves, predominantly to protect watersheds; interestingly, in a time of climate change we are once again realising that the mountains on the Continental Divide are the water towers of Western Canada.

Murphy follows that chapter with an interview with Edward Moberly, whose family ties in the Athabasca Valley extended from the fur trade in 1855 until the last of the Moberlys were evicted from the new Jasper Forest Park in 1909. Mr. Moberly’s vivid recollections add a very human touch to what can at times be dry reading.

The next four chapters address different aspects of tourism in the new park, from Mary Schäffer’s now-famous explorations and surveys of Maligne Lake to conversion of the public from packtrips to mass tourism by road and rail. While JNP is not as well known for mountaineering as its neighbouring parks to the south, it too attracted many eminent mountaineers and saw the shift from climbing expeditions led by Swiss guides to self-guided trips.

The final chapter is by Eric Higgs, a restoration ecologist who is now at the University of Victoria. Higgs argues that taking historical context into consideration is key to ecological restoration of the Athabasca Valley. Eric’s work in the area focussed on re-taking historical photographs from the exact same location and using these to interpret landscape change. Some of the differences are quite stunning, especially where forest now totally covers what were grasslands. The original photographer was Morrison Parsons Bridgland, a Dominion Land Surveyor, who had taken systematic photographs from peaks in the park. Higgs implies that the park did not know who the photographer was, but I vividly recall finding the small bound volumes of black-and-white photographs in 1981 in the park library, and knowing who the photographer was.

I recommend this book to anyone who has a serious interest in Jasper National Park and wants to understand more about the human history behind the wilderness curtain.

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The Riverscape and the River

By S. M. Haslam. 2008. Cambridge University Press, Cambridge and New York. 404 pages, 65 GBP, Cloth.

The Riverscape and the River, by Cambridge University fresh water ecologist S. M. Haslam, is a natural and social history of watercourses and their landscapes. Based on the author's 35+ years of work on rivers and their vegetation and waters, the book is a complex and comprehensive landscape ecology that describes mutual human and ecological impacts on riverscapes and waters.

The book is divided into 15 chapters organized into four basic parts. The first part is a series of introductory chapters presenting tracing from a landscape ecology perspective, and tracing human modification and destruction of waters and associated waterscapes, plants and animals. The rest of the book discusses resources related to rivers and riverscapes, including water resources and their losses; plants, animals and minerals; and human settlements, plus other social and cultural resources connected to watercourses.

Case studies of rivers and riverscapes from around the world, with a majority from Europe, illustrate the various chapters. The case studies are complex and varied, but one recurs often: Malta, the site of much of the author's research. Over the course of several chapters, a fascinating portrait of the island emerges, as well as a distressing picture of unwise water management.

Haslam calls the Malta case study a "sad tale" of a riverscape that changed from being wet, with surplus

water for human use, to dry, with little or no perennial surface water – all within 200 years. She adds that it should serve as a warning to other countries whose streams are shrinking and drying up, and recommends that planners visit Malta to see where their regions might be heading.

The wide range of topics covered by *The Riverscape and the River* results in a dense and somewhat overwhelming book – one that makes for a rather slow and laborious read, despite the many illustrations and summary tables. The latter are indeed helpful in sorting out much of the more heavily scientific details, but they do not necessarily help untangle the considerable overlap and repetition of subject matter. Nor do they help in clarifying the organization of the content, which didn't always make sense to me, perhaps because I have scant background in landscape ecology.

That said, the book is packed full of diverse and significant information. For the naturalist with a keen interest in water, and with the time and focus required to work through the dense and complex content, *The Riverscape and the River* provides a wealth of subject matter for understanding and appreciating the nature of contemporary rivers and riverscapes. The book has potential as a university-level textbook, but would have to be used carefully and wisely.

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MISCELLANEOUS

On the Wings of Cranes: Larry Walkinshaw's Life Story

By Lowell M. Schake. iUniverse, Inc. 1663 Liberty Drive, Bloomington, Indiana 47403. 2008. Softcover. 339 pages. 34.95 USD, Cloth.

Lowell Schake has thoroughly researched the life and work of North America's greatest nest finder, Larry Walkinshaw, the man who devoted his life to saving both the Kirtland's Warbler and the Whooping Crane from extinction. Also known as "The Father of International Studies of Cranes (Gruiformes)," throughout his life Walkinshaw demonstrated remarkable powers of observation, and self-discipline in his passionate pursuit of his ornithological endeavours.

Schake, Walkinshaw's son-in-law, had access to family records and appropriate photographs that were available to no one else. As attested by the long list of acknowledgments, Schake also searched widely and profitably in major archives and traveled widely for interviews. The result is an extremely interesting 339 page biography that tells of a Michigan dentist whose lifelong passion was the study of birds: "The theme of Walkinshaw's life is birding – inspiration its message."

One of the best tributes paid to Walkinshaw was made by Harold F. Mayfield, the only person to be president of all three major ornithological societies in North America. He singled out Walkinshaw as "a genius in finding nests, tireless in the field," and thereby his "model of the life history specialist." Mayfield also wrote Walkinshaw's memorial in *The Auk*, describing him as "a man of prodigious energy and determination," who "began a day's work before most people were awake, and he ended it after most people were asleep. ... As misers collect money, he collected data."

Walkinshaw was born on 25 February 1904 in Calhoun County north of Battle Creek, Michigan, raised on a 90-acre farm near the Big Marsh, and obtained all his formal education within Michigan. The Walkinshaw children walked or drove their horse and buggy along the edge of the marsh on their way to school. After attending high school in Bellevue, he took courses at nearby Olivet College preparatory to enrolling in dentistry at the University of Michigan, Ann Arbor. In June 1929 he was one of ten Honor Graduates in

Dental Surgery. In 1939 he took fall courses at Ann Arbor to learn root-canal surgery. This new skill provided the money which allowed him to travel widely. Indeed, he spent almost all his income on the purposeful acquisition of ornithological knowledge, and at his death left an unusually small estate for a professional man.

In October 1931, Larry married Clara Cartland, a minister's daughter born on a farm near Bashaw, Alberta, and later schooled at Fremont, 40 miles north of Grand Rapids. Their honeymoon was spent at the American Ornithologists' Union meeting at Detroit; this was a warning to Clara that birds played an inordinate role in Larry's life.

Meanwhile, Larry's studies of birds proceeded at a rapid pace. His first papers recorded the arrival of the European Starling, the wintering of the Turkey Vulture, and told of nests of the Black Tern, Dickcissel, Greater Prairie-chicken and Upland Sandpiper. In 1931 he studied his first nests of the Kirtland's Warbler and the Sandhill Crane. With his acute powers of observation, he quickly acquired vast amounts of data. Fortunately, he received enthusiastic support from Dr. Josselyn Van Tyne, the assistant curator of birds at Ann Arbor. Van Tyne showed infinite patience, recognizing Larry's unique talent in finding nests – among other feats, Larry recorded a prodigious 47 nests of the Virginia Rail – and his compulsion in recording the facts. Van Tyne told Larry, "You have a fine lot of biological data ... but they need a good deal of revising and polishing." For many years, preparation of a text sufficiently succinct and coherent enough for publication remained an almost insuperable difficulty for Larry, and Van Tyne's premature death in January 1957 deprived him of his most helpful critic.

Larry and Clara raised their son and daughter in a comfortable home, fortuitously situated across the street from a 100-acre abandoned farm. There, over 11 years, before and after spending the day in his dental office, he studied 613 nests of the Field Sparrow. Not surprisingly, when the final three volumes of *Bent's Life Histories* were edited by Oliver L. Austin, Walkinshaw wrote the 18-page account of the Eastern Field Sparrow, as well as that for Le Conte's Sparrow.

Larry's Kirtland's Warbler studies went into high gear when the population of singing males dropped to only 201 in 1971 and 167 in 1974. Five of eight Kirtland's Warbler nests contained cowbird eggs allowing only a single warbler fledgling to survive each parasitized clutch. The most prolific of the warbler females studied by Larry laid 38 eggs, of which 37 hatched, producing 32 nestlings over six summers. With pas-

sage of the U.S. Endangered Species Act in 1973 and use of 36 cowbird decoy traps, others exterminated 40 000 cowbirds from the main breeding area; nest parasitism fell from 65 percent to 21 percent of nests. By 2006, 1 478 Kirtland's singing males were counted and the occupied range had expanded.

Larry was one of the main searchers for the Whooping Crane nesting grounds in Canada, unknown since the early 1920s. The total count of Whooping Cranes in the wild was 17 in 1947 (they had reached a low of 15 in 1941) and they seemed doomed to inevitable extinction. Teams led by Fred Bard of Regina in 1945, by Olin Sewall Pettingill in 1945 and 1946, Robert P. Allen for the National Audubon Society in 1946-1950 and Larry Walkinshaw in Saskatchewan in 1947 and 1948 had all failed to find the nest areas, which were not discovered until 1954. Larry was a key member of the Whooper Club which morphed into the Whooping Crane Conservation Association.

Larry's field work is best represented by the data he left behind on 338 Kirtland's Warbler and 353 Sandhill Crane nests found in Michigan. In spite of difficulties and delays, Larry had three of his books printed: *The Sandhill Cranes* (Cranbrook Institute of Science 1949), *Cranes of the World* (Winchester Press, 1973), and *Kirtland's Warbler, the Natural History of an Endangered Species* (Cranbrook Institute of Science 1983, reprinted 1987). These represent one aspect of his legacy. Four others were "published" and stored only on microfilm for borrowing or purchase.

Larry, often with Clara, traveled throughout the world to study each crane species in its natural habitat as he prepared *Cranes of the World*. For the Wattle Crane, Larry determined the incubation period, their breeding cycle and their dance, causing Colonel Jack Vincent in Natal, South Africa, to say "within a few weeks you were able to receive a greater knowledge of our cranes than we have acquired in 25 years – to our shame." Larry "endured any hardship" and accepted "undue risk" during these crane studies.

At age 87, Larry contributed species accounts to *The Atlas of the Breeding Birds of Michigan*. He died a month short of his 89th birthday. The Walkinshaw name is perpetuated in the Walkinshaw Wetlands, a Sandhill Crane and Wetlands Management Area in Michigan, and by the Walkinshaw Crane Conservation Award of the North American Crane Working Group. *On the Wings of Cranes* is a worthy final tribute to a fine man and a remarkable ornithologist.

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Bird Banding in North America: The First Hundred Years

Edited by Jerome A. Jackson, William E. Davis, Jr., and John Tautin. 2008. *Memoirs of the Nuttall Ornithological Club, Memoir #15.* c/o Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138 USA. ix + 280 pages. 45 USD. Cloth.

This, the 15th memoir of the Nuttall Ornithological Club, is the proceedings of a day-long symposium, 26 September 2002, at the Third North American Ornithological Conference held in New Orleans. While Frank Moore's talk, "Bird banding and the study of migration," has been omitted, perhaps because the thousands of papers on the topic speak for themselves, John Tautin's paper "A History of the Bird Banding Laboratory 1920–2002," is an appropriate substitution.

The symposium celebrates the remarkable contributions of bird banding to ornithology. These contributions are summarized by three sentences in John Tautin's Preface: "Few, if any, tools have advanced our knowledge of birds as banding has. Few if any tools used by ornithologists have had such a history and culture with devotees, paraphernalia, organizations, publications, and lore. More than 66 million birds have been banded and 3,700,000 have been recaptured or re-sighted."

When aluminum became available in 1899, Hans Christian Mortensen marked 165 starlings in Denmark. In 1902–1903, Paul Bartsch banded 23 nestling Black-crowned Night-Herons near Washington, D.C. From 1914 to 1916, Alexander Wetmore banded 1241 birds in the Bear River marshes of Utah and obtained 182 recoveries. In 1920, Frederick C. Lincoln was made head of the U.S. government bird banding program. Working in close collaboration with the Canadian government, Lincoln promoted banding as "the sport which is also a Science." By the late 1920s, banding had grown by leaps and bounds and come of age as a scientific tool. The Bird Banding Laboratory, which moved from Washington to the Patuxent Refuge in Maryland during World War 2, "was, and still is, one of the longest running, most successful offices in the history of wildlife conservation."

Charles M. Francis, of the Canadian Wildlife Service, explains how the greatest value of banding data has been for monitoring avian survival rates, age ratios, productivity, recruitment and longevity. For game birds, harvest rates can be calculated. Glitches of various kinds arose, especially the severe band loss that occurred among gulls. James D. Nichols and John Tautin explain how, beginning in 1978, statistical models were developed for adult-only data and for data with both adults and young, to estimate survival and recovery

rates with greater precision. These involved optimization of goodness-of-fit tests and likelihood-ratio tests. Such statistical methods have made banding an important tool for managing game hunting.

Field studies of eco-toxicology would be almost non-existent if it were not for sophisticated controlled field studies made possible by banding. Banding studies have helped reveal whether a given population of birds is a "source" or a "sink." For example, banding showed that Brown-headed Cowbirds spend their mornings in breeding areas and their afternoons in feeding areas up to 18 km distant. Additionally, banding helps identify and map areas of threat to a given species. Banders also obtain fascinating and valuable scientific data about birds and their behaviour by weighing captured birds before release. For instance, banders measured the fat levels of the Semipalmated Sandpiper before its long distance migration from Massachusetts to the coast of Suriname.

Both human and avian health concerns are studied by banders who follow the avian carriers of West Nile virus, encephalitis, Lyme disease, mycoplasma, avian tuberculosis and malaria. For instance, from blood samples, they determine what percentage of Blue Jays carry which virus and what percent have antibodies, at which seasons and in what localities.

Identification of individual birds is the cornerstone of studies of bird behavior. Studies have progressed from anecdotal observations to hypothesis testing as banding provides the "best all-purpose, low-cost, and minimum-technology way to recognize individual birds in the field," and bands enable scientists to deepen their knowledge of bird behaviour and biology.

Banding has also proven itself to be an invaluable conservation tool. When species such as the Brown Pelican, Bald Eagle, Whooping Crane, Snail Kite, Red-cockaded Woodpecker, California Condor, and the Florida subspecies of the Grasshopper Sparrow showed drastic declines, banding techniques led to management practices that helped to save the species or increase its numbers.

The editors of this superb volume deserve fulsome praise, as does the Nuttall Club for making publication possible. Portraits of the leaders in banding increase the interest in this valuable compilation of a landmark conference. This book makes it clear how much ornithologists, bird lovers, and the general public have benefited from the science of bird banding.

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NEW TITLES

Prepared by Roy John

† Available for review * Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

ZOOLOGY

The Smartest Animals on the Planet. By S. Boysen and D. Cusance. 2009. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill Ontario L4B 1H1. 192 pages. 35.00 CAD, Cloth.

Bears – a Year in their Life. By M. Breiter. 2009. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 176 pages. 34.95 CAD, Paper.

The Second Atlas of Breeding Birds in New York State. Edited by K. McGowan and K. Corwin. 2009. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850. 696 pages. 59.95 USD, Cloth.

* **Birds of the Kingston Region [2nd Edition].** By Ron Weir. 2009. Kingston Field Naturalists, P.O. Box 831, Kingston, Ontario K7L 4X6. 611 pages. CAD, Paper.

* **Handbook of the Birds of the World. Volume 13.** Penduline-tits to Shrikes. Edited by Josep del Hoyo, Andrew Elliott, and David A. Christie. 2008. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 800 pages. 215,00 Euros, Cloth.

Sexual Coercion in Primates. Edited by M. Muller and R. Wrangham. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts. 472 pages. 55 USD.

* **A Photographic Guide to Seashore Life in the North Atlantic – Canada to Cape Cod.** By J. D. Sept. 2008. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 224 pages. 19.95 USD.

Sharks and Rays of Australia. By P. Lastand and J. Stevens. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts. 640 pages. 99.95 USD.

Super Suckers – The Giant Pacific Octopus and Other Cephalopods. By J. Cosgrove and N. McDaniel. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia, V0N 2H0 Canada. 208 pages. 26.95 CAD, Paper.

OTHER

* **Plains Apache Ethnobotany.** By J. Jordan. 2008. University of Oklahoma Press, 2800 Venture Drive, Norman, Oklahoma. 212 pages. 34.95 USD, Cloth.

Ecology and the Environment. Edited by D. Swearer. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts. 126 pages. 15.95 USD.

Nature Hikes – Near-Toronto Trails and Adventures. 2009. Firefly Books Ltd. 66 Leek Crescent, Richmond Hill Ontario L4B 1H1. 208 pages. 24.95 CAD, Paper.

A Guinea Pig's History of Biology. By J. Endersby. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts. 544 pages. 18.95 USD.

Parks and Nature Places Around Vancouver. Edited by A. Parkinson. 2008. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 192 pages. 24.95 CAD, Paper.

News and Comment

Marine Turtle Newsletter (121)

July 2008. 48 pages: ARTICLES: Trade Secrets: A Ten Year Overview of the Illegal Import of Sea Turtle Products (S. M. Rice & M. K. Moore) — In-water Observations of Recently Released Juvenile Hawksbills (*Eretmochelys imbricata*) (S. G. Dunbar, Lidia Salinas, & Larry Stevenson) — Special Theme Section: — Dhamra Port Development Debate, Orissa, India — Perspectives and Lessons: Editorials by Doug Hykle, Nicholas Mrosovsky, Kartik Shanker, Janaki Lenin & Rom Whitaker, Ashish Fernandes, Sudarshan Rodriguez & Aarthi Sridhar, Nicolas Pilcher, Holly T. Dublin, Amlan Dutta, Jack Frazier — MEETING REPORT — ANNOUNCEMENTS — IUCN-MTSG — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS — ACKNOWLEDGEMENTS.

The Marine Turtle Newsletter is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael S. Coyne (Managing Editor); Marine Turtle Newsletter, A321 LSRC, Box 90328 Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: mcoyne@seaturtle.org.

Errata Canadian Field-Naturalist 121(4) omission

Canadian Association of Herpetologists Association canadien des herpetologues Bulletin 15(1) Fall 2007

CONTENTS: Instructions for Authors — Editorial Notes — MEETINGS: CARCNet 20007 in Kingston, ON — Feature Article: Emerging infectious diseases in amphibians: Towards a concerted effort (David Lesbarreres, V. St. Amour, B. Pauli, and Tarner) — FIELD NOTES: Multiple scale habitat selection by Blanding's turtles in Algonquin Provincial Park (Christopher Edge) — BOOK REVIEW: "Naming Names: The Amphibian Tree of Life" by Frost and 18 coauthors 2006. American Museum of Natural History Bulletin 297: 1-230 (David Green, a self-review by one of the coauthors) — Thesis Abstracts in Canadian Herpetology (2007, MSc): UNIVERSITY OF OTTAWA, supervisor Gabriel Blouin-Demers: Marie-Andrée Carrière) "Movement patterns and habitat selection of common map turtles (*Graptemys geographica*) at St. Lawrence Islands National Park, Ontario, Canada"; LAURENTIAN UNIVERSITY (supervisor Jacqueline D. Litzgus): Jean J. Enneson "Population viability analysis and response to habitat change in Spotted Turtles (*Clemmys guttata*); William F. Greaves "A cold and harsh environ-

ment: demography and special ecology of a northern population of Wood Turtles (*Glyptemys insculpta*), Dan J. Reeves Modeling critical breeding habitat and body size in the federally endangered Spotted Turtle (*Clemmys guttata*); UNIVERSITY OF VICTORIA (supervisor Patrick T. Gregory): Liumila (Lita) Michelle Gomez "Habitat use and movement patterns of Northern Pacific Rattlesnake (*Crotalus o. oreganus*) in British Columbia"; MCGILL UNIVERSITY (supervisor David M. Green): Julie A. Lee-Yaw "The phylogenetic history of the Wood Frog (*Rana sylvatica*); Tricia Markle "Range limitations of stream salamanders in Quebec and Labrador", Shavonne J. Meyer "Landscape history, dispersal and the genetic structure of amphibian populations" — RECENT PUBLICATIONS in Canadian Herpetology: Citations 2006-2007 — ANNOUNCEMENTS: Remembering Ted David; ASIH Special Publications — Membership Form.

The CAH-ACH Bulletin is Edited by Jacqueline D. Litzgus, Department of Biology, Laurentian University, Sudbury, Ontario P3E 2C6, jlitzgus@Laurentian.ca.

Errata Canadian Field-Naturalist 122(2) omission

Pouliot, Yvan. 2008. Les collisions d'oiseaux à l'édifice Marly, St. Foy, Quebec, de 1978 à 2000, page

155. Remerciements: between Ouelett and Lessard add Pierre Richard.

Minutes of the 129th Annual Business Meeting of the Ottawa Field-Naturalists' Club 15 January 2008

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:30 pm
 Chairperson: Mike Murphy, President
 Attendance: Over thirty persons attended the meeting.

Attendees spent the first half-hour reviewing the minutes of the previous meeting, the Treasurer's report and the Report of Council. The meeting was called to order at 7:35 pm with some opening remarks from the President.

1. Minutes of the Previous Meeting

1. Under Members at Large; "Julia Cipriana" should read "Julia Cipriani"
 It was moved by Diane Lepage and seconded by Irwin Brodo that the minutes be accepted with minor amendments.
 (Motion Carried)

2. Business Arising from the Minutes

There was no business arising from the Minutes.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report

Frank Pope Frank began by acknowledging and thanking all of the many Club volunteers. He then presented the financial report for the year ending September 30, 2007, with the aid of some excellent on-screen visual aids. The Club's net assets have increased significantly due to substantial bequests from the Mildred Groh estate and the Victor John Macklin estate.

Moved by Frank Pope and seconded by Fenja Brodo that the Financial Report be accepted.
 (Motion Carried)

5. Committee Reports

Mike Murphy asked for questions and comments on the Committee reports which had been distributed to the attendees. He thanked the committee chairs and committee members for their work over the past year.

Moved by Eleanore Zurbrigg and seconded by Ken Allison, that the reports be accepted as ammended.
 (Motion Carried)

There was some discussion of Club membership trends and the opportunities that the new public focus on the environment might afford the Club.

6. Nomination of the Auditor

Moved by Frank Pope and seconded by Diane Lepage, that Janet Gehr continue as Auditor for another year.
 (Motion Carried)

7. Report of the Nominating Committee Fenja Brodo

Officers

President
 1st Vice President
 2nd Vice President
 Recording Secretary
 Treasurer

Ken Allison
 Ann Mackenzie
 vacant
 Annie Belair
 Frank Pope

Ex-officio members

Past President
 Business Manager
 Editor CFN
 Editor T&L

Michael Murphy
 Frank Pope
 Francis Cook
 Karen McLachlan-Hamilton
 Eleanor Zurbrigg

ON Nature Rep

Committee Chairs

Awards
 Birds
 Conservation
 Education & Publicity
 Excursions and Lectures
 Executive
 Fletcher Wildlife Garden
 Finance
 Macoun Club
 Membership
 Nominations
 Publications

see below
 Chris Traynor
 Stan Rosenbaum
 Gillian Marston
 Fenja Brodo
 Ken Allison
 Henry Steger
 Ann MacKenzie
 see below
 Henry Steger
 Fenja Brodo
 Ron Bedford

Members at large

Barbara Chouinard
 Julia Cipriani
 David Hobden
 Diane Kitching (Macoun)
 Diane Lepage
 Luke Periard
 Jeff Skevington

Chairs not on Council

Awards
 Macoun

Irwin Brodo
 Rob Lee

Retiring from the council: Susan Laurie-Bourque and Dan Millar

New on the council: Barbara Chouinard, Luc Periard, Jeff Skevington

Moved by Fenja Brodo and seconded by Irwin Brodo, that the slate of nominations for the 2008 Council be accepted.

(Motion Carried)

8. New Business

There was no new business.

9. Presentation

Fenja Brodo made presentations on behalf of the Club to Frank Pope, Mike Murphy and Susan Laurie-Bourque. She thanked Frank for ably filling so many

roles within the Club. Fenja also spoke of Bill Cody who is stepping down after a remarkable 58 years on Council. Attendees had the opportunity to sign a card for presentation to Bill. Council and the Club will miss him.

10. Adjournment

Moved by Diane Lepage and seconded by Diane Kitching that the meeting be adjourned at 8:45 pm.

(Motion Carried)

SUSAN LAURIE-BOURQUE
Recording Secretary

The Ottawa Field-Naturalists' Club Committee Reports for 2007

Awards Committee

The Awards Committee met in January to consider nominations made for the various OFNC awards, selected the candidates who best fit the criteria for each award, and recommended to the OFNC Council that six awards be given for volunteer contributions in 2006. The awards were presented at the OFNC's Annual Soiree, which took place April 28th 2007 at St. Basil's Church.

Member of the Year:

Annie Bélair – for her involvement with the Macoun Club, especially this year. She has been creative, innovative, and worked hard to get more members. She is also a volunteer at the Fletcher Wildlife Garden.

George McGee Service Award:

Christina Lewis – for her exceptional work, especially on the Birds Committee, her articles in *Trail & Landscape*, and ongoing natural history work especially Odonata.

Conservation Award – Member:

Frank Pope – in recognition of the successful completion of his work on Alfred Bog, with most of the bog now protected.

Conservation Award – Non-member:

Madeline Kallio – for her efforts in effectively keeping the National Capital's Wildlife Festival going, including organizing events and applying for grants.

Mary Stuart Education Award:

Isabelle Nicol – for effectively teaching nature programs to schools, gardening clubs and senior citizen's homes, using original materials, photos and other illustrative materials.

Ann Hanes Natural History Award:

Linda Jeays – for her study of the Eastern Tailed Blue Butterfly. Her careful observations since 2001 proved that the butterflies over-winter in the Ottawa Region, demonstrating what an amateur naturalist can do.

The full text of the citations for each of these awards was read at the soiree and will be published in 122(4) of *The Canadian Field-Naturalist*.

IRWIN BRODO
Chair, Awards Committee

Birds Committee

The Birds Committee organized the Fall Bird Count 2007 and with the Club des Ornithologues de l'Outaouais participated in the operation of the Christmas Bird Count 2006. We also organized a successful Peregrine Falcon Watch at the nest sight in downtown Ottawa. The Bird Record Subcommittee continues to review rare bird reports and is now doing much of its work via the internet. Again this season, the seed-a-thon was successful in raising money to operate the club's bird feeders. We continue to operate a rare bird alert and the Ottawa bird status line, a recorded telephone message of current bird sightings.

CHRIS TRAYNOR
Chair, Birds Committee

Computer Management Committee

The Computer Management Committee did not meet during 2007.

MICHAEL MURPHY
OFNC President

Conservation Committee

LAROSE FOREST

OFNC Council approved payment of \$4,000 to Ghislaine Rozon to help towards costs of \$15,000 awarded by the OMB against the appellants. In 2005 Ghislaine had been honoured by OFNC for her tireless efforts on behalf of the Forest. Christine Hanrahan represented the Club on the Advisory Committee, and led field trips. The United Counties of Prescott Russell invited OFNC to send representatives to a workshop on recreational uses, and Diane Lepage represented us there.

GACC/SIERRA CLUB OMB APPEAL ON LEITRIM

Council pledged an amount of \$1,000 towards expert witness expenses. So far payment has not been requested. The OMB Board denied the appeal at the prehearing stage. This was appealed to the OMB Chair and again denied. The appellants have since filed an application for a Judicial Review before Superior Court.

LETTERS

A letter was sent to Peaceful Parks Coalition for distribution to Ontario MLAs in opposition to further loosening of

the restrictions on destruction of cormorants, their eggs, and nests.

A letter was published by the Ottawa Citizen of September 25 supporting a provincial Greenways system, an urgent need for protection of the boreal forest, and the importance of reinstating outdoor environmental education for children.

A letter was sent to the Park Establishment Officer of Nahanni National Park Reserve, Ft. Simpson, NT, supporting preservation of the entire watershed of this internationally-recognized natural area when a pending decision on expanding the park boundaries is made.

"OTTAWA TALKS"

Bill Royds generously served as moderator of an innovative web-based program under the heading, "Ottawa's Natural Environment System: How Well is it Working?", sponsored by the City under a web-based series called "Beyond 20/20".

STAN ROSENBAUM
Chair, Conservation Committee

Education & Publicity

The committee created another set of display panels for the large club display using International Polar Year and Climate Change as the theme.

Committee members participated with displays at the National Wildlife Week's Wildlife Festival, several Environment Week events, the EcoFair at the RA Centre, an environment event at Bell's Corners United Church, the NAC Youth Orchestra concert and the OFNC Soiree.

Once again the OFNC participated in the Ottawa Science Fair sponsoring a prize for a project co-judged by Ed & Pub committee member Kathy Conlan.

The committee also arranged speakers for outside groups. Several digital photo presentations were also made by committee members.

GILLIAN MARSTON
Chair, Education and Publicity Committee

Excursions and Lectures Committee

This Committee took great pleasure in arranging (and attending) 25 trips, 4 work shops and ten monthly meetings as well as our annual Soirée. Twelve of these trips were devoted to birding, including a 4-day bus trip to Pointe Pelee National Park. Other trips emphasized mushrooms, ferns, wild flowers, mudpuppies, insects, and general natural history. We had several all-day excursions including our first ever Butterfly Count (to be repeated). The Fletcher Wildlife Garden is the venue for several nature walks and the Interpretation Centre a very good place for workshops. Monthly meetings were held at the Canadian Museum of Nature, but in a temporary space (Discovery Zone Theatre, 4th Floor) while the Museum continues to undergo renovations.

FENJA BRODO
Chair, Excursions and Lectures Committee

Executive Committee

The Executive Committee did not meet during 2007.

MICHAEL MURPHY
OFNC President

Finance Committee

The Finance Committee met twice during the year, once on March 5th and again on September 6th. Highlights include:

A Funding Request Policy was developed and approved by Council stipulating how requests for funds outside of the usual budgeting process should be handled.

The CFN is getting on a more solid financial footing with the increase in publication fees. The use of the Manning Fund was also extended to cover the page charges of articles that are not just on topics related to Northern Canada.

The Club received a bequest of \$180,000 from the estate of Victor John Macklin.

A proposed budget for 2007-2008 was developed and submitted to Council. A deficit of \$9,490 was forecast for the Club and a deficit of \$7,700 was forecast for the Canadian Field-Naturalist.

ANN MCKENZIE
Chair, Finance Committee

Fletcher Wildlife Garden

The Fletcher Wildlife Garden has completed another successful year. Wildlife continues to make good use of it and several new species have been added to our lists. The Management Committee met 11 times and held an end-of-season volunteer appreciation event, attended by over 30 people.

Volunteers contributed over 3600 hours, working individually or in groups on Friday and Sunday mornings or Wednesday evenings. Work focused on improving the Butterfly Meadow and controlling invasive species, with pale swallow-wort still a major problem. In the Backyard Garden, the pond was completely reconstructed and a bench in memory of long-time volunteer Dale Crook was built and installed. A pergola was added to the front of the Interpretation Centre as a memorial to OFNC member Eileen Evans using funds donated by her children supplemented from the Groh bequest and with architectural services provided by OFNC member J. Walmsley. Signs were erected to name areas of FWG and provide brief descriptions of each.

The FWG was used for Macoun Club meetings, 3 club workshops and 5 walks, including the annual International Migratory Bird Day walk and a workshop on pollinators. Carleton University geography students provided us with a visitor survey while other school, scout, student and corporate groups came for volunteer work or educational activities. Our volunteers gave talks and advice to various groups from Greely, Portland, Niagara, and Ottawa.

Our annual native plant sale raised over \$2500 this year and donations (excluding those for the pergola) amounted to over \$500. A grant from HRSD allowed us to employ a summer student for 10 weeks. He carried out research on water quality to help us understand how to maintain the health of our Amphibian Pond, which is suffering the effects of eutrophication. In addition, he staffed the Interpretation Centre, helped volunteers, prepared material for displays, made and recorded wildlife observations, and provided weekly nature activities for a children's day camp from Carleton University.

Over 4000 visitors a month use our web site – www.ofnc.ca/fletcher.php – to learn about wildlife gardening and local natural history.

DAVID HOBDEN
Chair, Fletcher Wildlife Garden Committee

Macoun Club Committee

The Committee met just once at the beginning of the year to set the Club's overall direction, with the month-to-month planning being handled by telephone and email. Committee members supervised or gave presentations at 17 indoor meet-

ing, and led 16 field trips. All meetings were held in the Fletcher Wildlife Garden building (rather than the Museum of Nature, which is under renovation).

For three years now there have been no high-school aged members, but the younger age groups are strong. There is also always interest from families with children under age 8, which we cannot accommodate.

The Club produces a monthly newsletter, an annual publication (The Little Bear) and maintains a website that is linked to the OFNC site. Additionally, the Macoun Club's group notebook on sightings in the Club's nature-study area in the Greenbelt near Bells Corners is being bound in hard-cover each year, and distributed to members.

ROBERT E. LEE
Chair, Macoun Field Club

Membership Committee

The distribution of the membership for 2007 is shown in the table (below), with the corresponding numbers for 2006 in brackets. "Others" represent, for the greatest part, affiliate organizations that receive complimentary copies of the Club's publications. Local membership (within 50 km of Parliament Hill) was 680 and 651 in 2006 and 2007, respectively. The reduction of 27 in total membership is a continuing challenge to the Club.

H. STEGER
Chair, Membership Committee

	CANADIAN	USA	OTHER	TOTAL
Individual	398 (401)	17 (16)	3 (5)	418 (422)
Family	312 (332)	1 (1)	2 (2)	315 (335)
Sustaining	15 (9)	0 (0)	0 (0)	15 (9)
T and L	2 (6)	0 (0)	0 (0)	2 (6)
Honorary	23 (25)	0 (0)	0 (0)	23 (25)
Life	42 (42)	6 (6)	1 (1)	49 (49)
Other	27 (30)	1 (1)	1 (1)	29 (32)
TOTAL	819 (845)	25 (24)	7 (9)	851 (878)

Publications Committee

The Publications Committee met twice in 2007.

Four issues of *The Canadian Field-Naturalist* were published in 2007: Volume **119** (2005) (4) and Volume **120** (2006) (1,2, and 3). These four issues contained 570 pages; 58 articles; 18 notes; 62 book reviews; 240 new titles; 2 commemorative tributes; 21 pages of News and Comment; 4 pages of miscellany; and a 32 page index. The conditions for use of the Manning Fund interest were modified slightly. As a result, \$13,323 were drawn, compared to none in the past two years. Page charges have been increased about 10% beginning with Volume **121**. Efforts to reduce the journal deficit appear to

be succeeding. The publication of an electronic version of *The Canadian Field-Naturalist* was further considered. The Webmaster has devised a method for allowing only duly registered members and subscribers to access this version. Trials of this system are being made.

Volume **41** of *Trail & Landscape* was published in four issues containing 232 pages. The 20-year index for Volumes **21 – 40**, 1987 – 2006 is nearing completion.

Respectfully submitted,

RONALD E. BEDFORD
Chairman, Publications Committee

Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the statement of financial position of THE OTTAWA FIELD-NATURALISTS' CLUB as at September 30, 2007, the statement of changes in net assets, the statement of operations, and the statement of cash flows for the year then ended. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these financial statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with Canadian generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, THE OTTAWA FIELD-NATURALISTS' CLUB derives some of its revenue from donations and fund-raising activities. These revenues are not readily susceptible to complete audit verification. Accordingly, my verification of these revenues was limited to the amounts recorded in the records of THE OTTAWA FIELD-NATURALISTS' CLUB, and I was not able to determine whether any adjustments to the recorded amounts might be necessary.

In my opinion, except for the effects of adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenue referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the organization as at September 30, 2007, and the results of its operations and cash flows for the year then ended in accordance with Canadian generally accepted accounting principles.

JANET M. GEHR

C.A., Licensed Public Accountant

North Gower, ON
January 12, 2008

The Ottawa Field-Naturalists' Club Statement of Financial Position September 30, 2007

	2007	2006
ASSETS		
CURRENT		
Cash	\$51,190	\$26,480
Investment certificate (Note 1)	196,498	15,145
Marketable securities (Note 2)	0	31,187
Accounts receivable	7,937	31,491
	<u>255,625</u>	<u>104,303</u>
LAND - ALFRED BOG		
(At cost, assessed value \$19,100)	3,348	3,348
Marketable Securities (Note 2)	<u>328,725</u>	<u>315,501</u>
	<u>\$587,698</u>	<u>\$423,152</u>
LIABILITIES AND FUND BALANCES		
CURRENT		
Accounts payable and accrued liabilities	\$3,096	\$2,500
Deferred revenue	7,335	11,688
	<u>10,431</u>	<u>14,188</u>
LIFE MEMBERSHIPS	<u>15,011</u>	<u>14,079</u>
NET ASSETS		
Unrestricted	320,218	145,238
Club reserve	100,000	100,000
Manning principal	100,000	100,000
Manning interest - OFNC	2,882	1,948
- CFN	19,559	24,225
Seedathon	46	329
Anne Hanes memorial	788	788
de Kiriline-Lawrence	13,603	17,174
Macoun Baillie Birdathon	1,183	1,253
Alfred Bog	3,977	3,930
	<u>562,256</u>	<u>394,885</u>
	<u>\$587,698</u>	<u>\$423,152</u>

The Ottawa Field-Naturalists' Club
Statement of Operations
For the year ended September 30, 2007

	2007	2006
REVENUE		
Memberships	\$14,651	\$13,490
<i>Trail and Landscape</i>	99	146
Interest	2,565	2,730
GST rebate	1,016	1,005
Other	1,223	623
	<u>19,554</u>	<u>17,994</u>
OPERATING EXPENSES		
Affiliation fees	225	625
Computer	2,406	841
Memberships	1,185	836
Office assistant	1,300	1,275
Telephone	2,115	1,782
Insurance	725	725
Audit	2,000	2,000
GST	2,053	1,460
Other	3,242	946
	<u>15,251</u>	<u>10,490</u>
CLUB ACTIVITY EXPENSES		
Awards	0	232
Birds	849	385
Conservation	12	
Education and publicity	2,714	2,627
Excursions and lectures	-1,187	832
Macoun Field Club	546	1,139
Soiree	-60	46
Trail and landscape	10,457	10,014
Fletcher Wildlife Garden (Note 4)	410	2,321
Other	210	323
	<u>13,951</u>	<u>17,919</u>
Deficit, End of Year	<u>(\$9,648)</u>	<u>(\$10,415)</u>

The Ottawa Field-Naturalists' Club
Statement of Cash Flows
For the year ended September 30, 2007

	2007	2006
Cash Flows from Operating Activities		
Excess (expenditures) revenue for the year	(\$17,025)	\$22,378
Net change in non-cash balances	<u>19,797</u>	<u>-10,015</u>
(Decrease) in Cash from Operating Activities	<u>2,772</u>	<u>-32,393</u>
Cash Flows From Financing and Investing Activities		
Contributions of cash from endowments	181,226	23,717
Contributions of cash from donations and fundraising	16,819	12,404
Increase in Life Memberships	932	0
Cash used for fund activities	-13,649	-11,469
Net purchase and sale of investments	<u>17,963</u>	<u>-7,854</u>
	<u>203,291</u>	<u>16,798</u>
Net (Decrease) Increase in Cash and GIC	206,063	-15,595
Cash and GIC, beginning of year	<u>41,625</u>	<u>57,220</u>
Cash and GIC, end of year	<u>\$247,688</u>	<u>\$41,625</u>
Net Change in Non-Cash Balances		
Accounts receivable	\$23,554	\$#,9654)
Prepaid expenses	0	1,000
Accounts payable and accrued liabilities	596	-1,000
Deferred revenue	<u>-4,353</u>	<u>-361</u>
	<u>\$19,797</u>	<u>(\$10,015)</u>

The Ottawa Field-Naturalists' Club
Canadian Field-Naturalist – Statement of Operations
For the year ended September 30, 2007

	2007	2006
REVENUE		
Memberships	\$9,767	\$9,311
Subscriptions	9,275	24,314
Reprints	3,721	5,267
Publication charges	19,831	27,470
Interest and exchange	10,566	10,829
GST rebate	2,921	1,542
Other	1,458	1,299
	<u>57,539</u>	<u>80,032</u>
EXPENSES		
Publishing	36,061	57,735
Reprints	1,900	3,832
Circulation	7,156	9,678
Editing	2,694	1,856
Office assistant	5,000	5,000
Honoraria	9,000	9,000
GST	2,695	4,870
Other	410	24
	<u>64,916</u>	<u>91,995</u>
Excess Expenses Over Revenue	<u>(\$7,377)</u>	<u>(\$11,963)</u>

The Ottawa Field-Naturalists' Club Statement of Changes in Net Assets
For the Year Ended September 31, 2007 (Note 5 for footnotes)

Net Assets	Beginning Balance	Excess Expenses CFN	Excess Expenses OFNC	Other Revenue	Other Expenses	Ending Balance
Unrestricted	\$145,238	(\$7,377)	(\$9,648)	\$192,005 a)	\$—	\$320,218
Club reserve	100,000	0	0	0	0	100,000
Manning Principal	100,000	0	0	0	0	100,000
Manning - CFN	24,225	0	0	3,735	-8,401 b)	19,559
Manning - OFNC	1,948	0	0	934	0	2,882
Seedathon	329	0	0	825	-1,108 c)	46
Anne Hanes Memorial	788	0	0	0	0	788
de Kiriline-Lawrence	17,174	0	0	429	-4,000 d)	13,603
Macoun Baillie Birdathon	1,253	0	0	70	-140	1,183
Alfred Bog	3,930	0	0	47	0	3,977
	<u>\$394,885</u>	<u>(\$7,377)</u>	<u>(\$9,648)</u>	<u>\$198,045</u>	<u>(\$13,649)</u>	<u>\$562,256</u>

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

September 30, 2007

1. Nature of Business

The organization is non-profit and incorporated under the laws of Ontario (1884). The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

The organization's financial instruments consist of cash, accounts receivable, marketable securities, and accounts payable. Unless otherwise noted, it is the management's opinion that the organization is not exposed to significant interest, currency, or credit risks arising from these financial instruments. The fair value of these instruments approximate their carrying values, unless otherwise noted.

3. Capital Assets

Capital assets in excess of \$4,000 cost are recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

4. Revenue Recognition

Revenue is recognized when earned except for donations and fund-raising, which is recognized when received.

5. Foreign Currency

Transactions during the year in U.S. dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in U.S. dollars at year-end have been converted to Canadian dollars at the rate effective on Sept. 30, 2007.

Gains or losses resulting therefrom are included in revenue or expenses.

Notes (continued)

Precision of descriptors for percent marrow fat content for Whitetailed Deer, <i>Odocoileus virginianus</i>	L. DAVID MECH	273
Cliff roosting by migrant Semipalmated Sandpipers, <i>Calidris pusilla</i> , at Farrier's Cove, Shepody Bay, New Brunswick	COLIN M. MACKINNON, JULIE DULUDE, ANDREW C. KENNEDY, SOPHIE J. E. SURETTE, and PETER W. HICKLIN	274

Book Reviews

ZOOLOGY: Birds of the Kingston Region [Second Edition] — Handbook of the Birds of the World. Volume 13. Penduline-tits to Shrikes — The Return of Caribou to Ungava — A Photographic Guide to Seashore Life in the North Atlantic: Canada to Cape Cod		277
BOTANY: Glistening Carnivores: The Sticky-Leaved Insect-Eating Plants — Trees and Shrubs of Minnesota		280
ENVIRONMENT: Major Invasive Organisms in Agriculture of China — Lost Worlds of the Guiana Highlands — Culturing Wilderness in Jasper National Park: Studies in Two Centuries of Human History in the Upper Athabasca River Watershed — The Riverscape and the River		283
MISCELLANEOUS: On the Wings of Cranes: Larry Walkinshaw's Life Story — Bird Banding in North America: The First Hundred Years		286
NEW TITLES		289

News and Comment

Marine Turtle Newsletter (121) — Errata Canadian Field-Naturalist 121(4) omission: Canadian Association of Herpetologists/Association Canadian des Herpetologues Bulletin 15(1) Fall 2007 — Errata Canadian Field-Naturalist 122(2) omission		290
Minutes of the 129 th Annual Business Meeting of The Ottawa Field-Naturalists' Club 15 January 2008		291

Mailing date of the previous issue 122(2): 19 November 2009

Articles

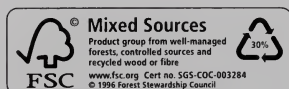
- A survey of lichens and bryophytes in White Spruce, *Picea glauca*, tree islands on a calcareous beach ridge in northeastern Manitoba MICHELE D. PIERCEY-NORMORE 19
- Late-winter habitat use by Mule Deer, *Odocoileus hemionus*, in central interior British Columbia GILBERT PROULX 20
- Factors influencing the abundance of berry plants for Black Bears, *Ursus americanus*, in Quebec RÉMI HÉBERT, CLAUDE SAMSON, and JEAN HUOT 21
- Spatial interactions of yarded White-tailed Deer, *Odocoileus virginianus* MICHAEL E. NELSON and GLEN A. SARGEANT 22
- Pileated Woodpeckers, *Dryocopus pileatus*, foraging in suburban habitats in New Brunswick ANTHONY J. ERSKINE 23
- Evidence of arboreal lichen use in peatlands by White-tailed Deer, *Odocoileus virginianus*, in northeastern Alberta A. DAVID M. LATHAM and STAN BOUTIN 24
- Effects of forest cover on fruit set in the woodland herb, *Maianthemum canadense* (Liliaceae) HISATOMO TAKI, PETER G. KEVAN, and YUICHI YAMAURA 25
- Habitat use by the Eastern Sand Darter, *Ammocrypta pellucida*, in two Lake Champlain tributaries SHANNON M. O'BRIEN and DOUGLAS E. FACEY 26
- Winter predation by River Otter, *Lontra canadensis*, on Tautog, *Tautoga onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a review of evidence for resident relict populations of the Tautog in Nova Scotia and New Brunswick JOHN GILHEN and KIM AABOE 27
- Comparisons and trends in White-tailed Deer, *Odocoileus virginianus*, body fat in northeastern Minnesota, 1974-1990 KERRY L. NICHOLSON, WILLIAM J. PETERSON, and WARREN B. BALLARD 28

Notes

- First record of a collapsed dorsal fin in a White-beaked Dolphin, *Lagenorhynchus albirostris*, with a gunshot wound as a possible cause JEFF W. HIGDON and DAVE SNOW 29
- Characteristics of Porcupine, *Erethizon dorsatum*, winter den-sites in living trees in Wisconsin LORI L. NATZKE and RICHARD P. THIEL 30
- Diurnal above-ground movement in Hairy-tailed Moles, *Parascalops breweri* E. FRASER and JOHNSTON F. MILLER 31
- Egg predation at a Golden Eagle, *Aquila chrysaetos*, nest MARTIN L. MORTON and MARIA E. PEREYRA 32
- Differential footload of male and female Fisher, *Martes pennanti*, in Quebec AURELIE RENARD, MAXIME LAVOIE, and SERGE LARIVIÈRE 33
- Eastern Coyotes, *Canis latrans*, observed feeding on Periodical Cicadas, *Magicicada septendecim* JONATHAN G. WAY 34

(continued on inside back cover)

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COVER: Grizzly Bear *Ursus arctos*, photographed in Wapusk National Park, Manitoba on 9 August 2008 by Linda Gormezano. See article by Rockwell, Gormezano, and Hedmen. See pages 323-326.

The Canadian Field-Naturalist

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The Density of Beaver, *Castor canadensis*, Activities along Camrose Creek, Alberta, within Differing Habitats and Management Intensity Levels

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Loates, Bethany M., and Glen T. Hvenegaard. 2008. The density of Beaver, *Castor canadensis*, activities along Camrose Creek, Alberta, within differing habitats and management intensity levels. *Canadian Field-Naturalist* 122(4): 299-302.

Beaver (*Castor canadensis*) occupy a variety of habitats in North America, but prefer Aspen (*Populus tremuloides*) and willow (*Salix* spp.) for food and construction materials. Beaver landforms, such as dams, can cause many problems for landowners, resulting in varied management efforts, such as dam dismantling and Beaver removal. The goal of this study was to compare the density of Beaver activity along Camrose Creek, Alberta, among a variety of habitats and management intensities. Along this 35 km creek there were an average of 0.46 food caches/km, 0.57 lodges/km, and 3.06 dams/km (of which 1.66/km were altered by people and 1.40/km were unaltered). There were more caches, lodges, and unaltered dams in Trembling Aspen forests compared to other habitats. Areas with some management had more food caches and either altered or unaltered dams than areas with no management.

Key Words: Beaver, *Castor canadensis*, density, habitat, management, Alberta.

Beavers (*Castor canadensis*) are found in streams, ponds, and lake edges throughout most of Canada and the United States south of the tree line (Jenkins and Busher 1979; Muller-Schwarze and Sun 2003). Beavers eat leaves, twigs, and bark of most species of deciduous trees and shrubs, with a preference for Trembling Aspen (*Populus tremuloides*) and willow (*Salix* spp.) that grow near water, along with many herbaceous plants (Jenkins and Busher 1979). Beavers typically colonize areas where foraging can take place within 100 m of the water (Jenkins 1980; Skinner 1984).

Beavers construct dams, lodges, food caches, trails, and canals for protection and foraging. Dams are interwoven structures built from rocks, logs, grass, and mud to impound water along streams (Muller-Schwarze and Sun 2003). The resulting ponds provide year-round habitat and allow Beavers to easily transport logs and branches in the summer. Lodges, the principal shelter for a Beaver colony, are occupied for several years (Dieter and McCabe 1989), providing protection from the cold, heat, and predators (Muller-Schwarze and Sun 2003). Each Beaver colony has an average of 4-8 Beavers and 1-3 lodges (Jenkins and Busher 1979). Normally, each colony has one food cache (Broschart et al. 1989), a pile of submerged branches stored in the fall for consumption during the winter (Swenson et al. 1983). Trails are well-worn paths created by walking

and dragging tree limbs. Canals are deeper-cut trails or dredged channels filled with water (Butler and Malanson 1994).

Beaver activities are both beneficial and problematic for landowners (Hammerson 1994). Beaver activities help increase aquatic structural diversity, stabilize the water table, and open forest canopies. However, Beaver activities can also flood neighboring land, damage preferred plants, and create public safety concerns (Schulte and Muller-Schwarze 1999). As a result, many Beaver populations around human settlements are managed. In some cases, Beaver numbers are maintained at a level deemed acceptable, and in other cases all Beavers are kept out of specific areas (Schulte and Muller-Schwarze 1999). Typical controls include harvesting, sterilizing, or relocating Beavers, removing dams, introducing natural predators, protecting individual trees, managing water levels, and using Beaver repellants (Schulte and Muller-Schwarze 1999). Not all controls are feasible due to costs or logistics, and success in controlling Beaver numbers by these methods varies considerably (Hammerson 1994).

Along Camrose Creek in east-central Alberta, Beaver management typically occurs from April to September. Dams are removed with manual labour, back hoe tractors, or dynamite. Sporadically, Beaver repellants such as flow-through pipes are used with little success.

Harvesting is conducted through controlled shooting or lethal trapping by landowners or municipal officials. Occasionally, Beavers are live-trapped and relocated.

There is little local information about Beaver density, habitat preferences, and management effectiveness. Thus, the goal of this study was to determine the density of Beaver activities along Camrose Creek, and to compare density among a variety of habitats and management intensities. We predicted that Beaver colony density would be higher within aspen forests than in other habitats such as urban areas, farmland, and badlands. We also predicted that Beaver density would be lower in areas with more intensive management than in areas with less intensive management.

Methods

Camrose Creek, 35 km in length, is located within the Aspen parkland ecoregion of Alberta, 90 km south-east of Edmonton (Figure 1). The creek starts at the Lyseng reservoir outflow (53°06'15"N, 112°52'45"W), meanders south through privately owned farmland, passes through the city of Camrose, cuts through a narrow valley, and empties into the Battle River (52°56'45"N, 112°52'30"W). We walked the entire creek in October and November, 2005. Inventory methods generally followed those of the British Columbia Ministry of Environment, Lands, and Parks (1998). With the help of aerial photographs and 1:20 000 scale topographic maps, we noted the location of all food caches, lodges, and dams. Dams were subdivided into unaltered dams (no evident sign of human management) or altered dams (dams that had signs of mud, logs, and branches removed within the past two years). For analysis, the creek was divided into 1 km-long segments.

Using visual observations of the dominant habitat within 60 m on both sides of the creek, we categorized each creek segment as: (1) farmland for cereal crops and grazing; (2) urban areas, with paved paths or buildings; (3) Trembling Aspen forest; and (4) badlands with short grasses, shrubs, and heavily eroded creek banks.

To determine the intensity of human management of Beavers in the past two years, we conducted telephone interviews with farmers, municipal officials, and wildlife managers who owned land or had management responsibilities along the creek. Based on their responses, we classified the intensity of Beaver management for each creek segment into one of four categories: (1) high – Beaver removal and dam dismantling; (2) medium – Beaver removal only; (3) low – dam dismantling only; and (4) none – no management. We also classified the intensity of Beaver management into two categories, some Beaver removal and/or dam dismantling versus no management.

Using SPSS 11.0, we examined potential differences in Beaver density among varying habitats (four categories) and management intensities (four categories

and two categories) by using one-way analyses of variance and t-tests. We conducted post-hoc multiple comparisons with Tukey's honestly significant difference (HSD) test. We set significance levels at $P < 0.05$.

Results

Along Camrose Creek, we recorded 16 food caches (average of 0.46/km), all of which were in the lower 23 km (resulting in an average of 0.70/km for that stretch). We also recorded 20 lodges (0.57/km), 49 unaltered dams (1.40/km), and 58 altered dams (1.66/km). Of the 35 1 km-long creek segments, we classified 13 km as farmland habitat, 11 km as aspen forest, 6 km as urban areas, and 5 km as badlands (Table 1). The creek surveyed began within farmland, passed through city and aspen habitats, and flowed through badland habitat toward the confluence with the river. The number of food caches, lodges, and unaltered dams was significantly different among habitats. Aspen forest habitat contained more food caches than the badland or farmland habitats (Tukey's HSD < 0.05). Farmland had fewer lodges than badland or aspen forest habitats (Tukey's HSD < 0.05). Aspen forest habitats had more unaltered dams than farmland habitats (Tukey's HSD < 0.05). The number of altered dams did not differ by habitat.

The level of management intensity changed frequently along the creek. We classified 12 km as high management intensity, 3 km as medium, 7 km as low, and 13 km with none (Table 2). Using four categories of management intensity, there was no significant difference between management intensity and the number of food caches, lodges, unaltered dams, and altered dams. Using only two management intensity levels (some or none), areas with some management had significantly more food caches, unaltered dams, and altered dams than areas with no management (Table 3).

Discussion

Based on the assumptions that one food cache indicated one Beaver colony and that the average colony held 4–8 Beavers (Jenkins and Busher 1979), we concluded that the total population of Beavers along Camrose Creek in 2005 was between 64 and 128. Further refinement of population estimates would require additional indices, such as visual animal counts, track density, and cache size (Easter-Pilcher 1990; Osmundson and Buskirk 1993).

The average density of Beaver colonies along the entire length of Camrose Creek was 0.46/km (and 0.70/km for the lower 23 km). Summarizing several studies, Jenkins and Busher (1979) reported that the density of Beaver colonies ranged between 0.40/km and 0.80/km. In boreal Minnesota, density ranged between 0.13/km in 1940 and 2.23/km in 1981 (Brochart et al. 1989). In California, density was 0.72/km in the Truckee River and 0.20/km along its tributaries (Beier and Barrett 1989). Similar densities were found

in interior Alaska (0.63/km; Boyce 1981), northwest Wyoming (0.90/km; Collins 1976), and central Massachusetts (0.83/km; Howard and Larson 1985).

The average density of dams (both altered and unaltered) in Camrose Creek was 3.06/km. The comparable densities in Quebec (North shore of the Gulf of St. Lawrence; Naiman et al. 1986) and northern Minnesota (Naiman et al. 1988) were 10.60/km and 2.50/km, respectively. There is little comparative information on the density of lodges, trails, or canals.

As expected, the density of Beaver activity was higher in aspen forest habitats than in other habitat types. Aspen trees are the preferred source of food and construction material for Beavers (Jenkins and Busher 1979). Nevertheless, Beavers found in the city and badland habitats obviously found enough food and construction material to survive (i.e., willow, alder [*Alnus* spp.], and White Birch [*Betula papyrifera*]). Because the farmland stretches of the creek contained no colonies, it is likely that the dams present were not active. The low number of altered dams in the city may reflect the presence of a lake in the city (making it difficult for Beavers to construct dams) or the reluctance of officials to manage dams within the city limits.

In creek segments with some Beaver management, there were more caches, unaltered dams, and altered dams than in areas with no management. These results (except for the latter) were contrary to our predictions, and might reflect the landowners' efforts to concentrate Beaver control activities in areas with high Beaver densities to keep those densities at levels acceptable to landowners. Moreover, little or no management is needed where there is little Beaver activity. Thus, this study could not determine if management intensity has an effect on the density of Beaver populations.

There are several limitations to this study. First, the 1 km-long segments of the creek that were used for units of analysis may have masked finer-scale changes in habitat and management efforts. Second, designating management intensity levels had potential problems. Even though we interviewed all landowners and managers along the creek as to which Beaver management techniques they employed, we did not determine the frequency or success of those techniques. Moreover, we found some inconsistent results (e.g., altered dams within segments reported to have had no dams dismantled).

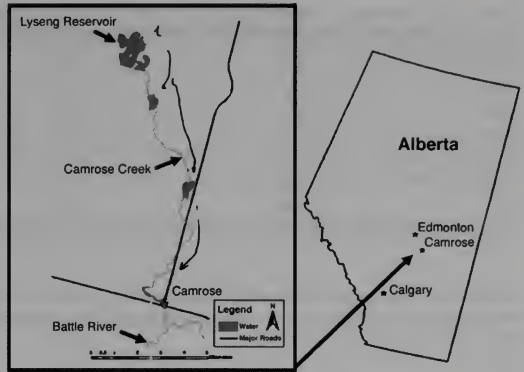


FIGURE 1. Location of Camrose Creek in east-central Alberta, where Beaver density, habitat, and management intensity were measured in 2005.

Further research should focus on Beaver activity densities using finer-scale analyses of habitat suitability and management intensity. A study over several years would provide valuable data to help understand changes in Beaver populations, habitat preferences, and management effectiveness. Other research could examine the effectiveness of alternative forms of management (Hammerson 1994), foraging strategies within habitats (Basey et al. 1988; Fryxell 1992), and the critical thresholds for distance to food resources for successful Beaver colonies (Fryxell and Doucet 1991).

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TABLE 1. Differences in Beaver activity density (per km) among four habitat types.

Habitat Type	Caches	Lodges	Unaltered dams	Altered dams
Farmland	0.00 ^a	0.00 ^a	0.38 ^a	1.92
Badland	0.40 ^a	0.80 ^b	1.50 ^{ab}	2.80
City	0.50 ^{ab}	0.50 ^{ab}	1.50 ^{ab}	0.33
Aspen forest	1.00 ^b	1.18 ^b	2.64 ^b	1.55
F (df = 3)	13.160	8.980	6.309	1.076
P	<0.001	<0.001	0.002	0.373

^{a,b}Where superscripts are different there is a statistical significance between habitats at *P* < 0.05, using Tukey's HSD test.

TABLE 2. Differences in Beaver activity density (per km) among four management intensity levels.

Management Intensity Caches		Lodges	Unaltered dams	Altered dams
None	0.20	0.33	0.67	0.67
Low	0.80	1.00	1.60	2.00
Medium	0.33	0.33	1.33	0.67
High	0.67	0.75	2.25	3.00
F (df = 3)	2.606	1.476	2.760	2.712
P	0.069	0.240	0.059	0.062

TABLE 3. Differences in Beaver activity density (per km) between two management intensity levels.

Management Intensity Caches		Lodges	Unaltered dams	Altered dams
None	0.20	0.33	0.67	0.67
Some	0.65	0.75	1.95	2.40
t (df = 33)	2.530	1.695	2.651	2.226
P	0.016	0.099	0.012	0.030

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River Otter, *Lontra canadensis*, Food Habits in the Missouri Ozarks

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⁵ Deceased

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The reintroduction of River Otters (*Lontra canadensis*) between 1982 and 1992 resulted in widespread occurrence of the species throughout the Missouri Ozarks. This study examined otter diets from the vicinity of two Ozark streams in relation to seasonal and spatial trends. Otter scats (N = 4750) were collected and analyzed from the Osage Fork River and Big Piney River during the summer and winter seasons of 2001 and 2002. During the winter (January-March), fish occurred in 86% of the samples. During the summer (June-August), occurrence of fish dropped to approximately 15% for both rivers. Seven families of fish were identified in the diets, with Centrarchidae being most common regardless of river or season. Within the Centrarchidae, the genus *Lepomis* (mostly Longear Sunfish, *Lepomis megalotis*) was most common, with *Micropterus* (mostly Smallmouth Bass, *Micropterus dolomieu*) and Rock Bass (*Ambloplites rupestris*) also well represented. The mean age of *Ambloplites* consumed (\bar{x} = 3.3 years) was consistently older than that of either *Micropterus* (\bar{x} = 2.54 years) or *Lepomis* (\bar{x} = 2.78 years). Crayfish were recovered from a mean of 85.2% of scats in the winter and 99% in the summer. Smaller fish and crayfish were more common from the upper reaches of the streams while larger fish were prevalent in the lower reaches.

Key Words: River Otter, *Lontra canadensis*, *Lutra canadensis*, diet, food habits, predator, crayfish, fish, Centrarchidae.

River Otters, *Lontra canadensis*, were reintroduced in Missouri during a 10-year program initiated in 1982. River otters in North America are known to consume primarily fish and crayfish, although there is great regional variation (Lagler and Ostenson 1942; Greer 1955; Ryder 1955; Hamilton 1961; Knudsen and Hale 1968; Sheldon and Toll 1964; Grenfell 1974; Toweill 1974; Lauhachinda 1978; Gilbert and Nancekivell 1982; Anderson and Woolf 1987; Tumilson and Karnes 1987; Reid et al. 1994).

In addition to regional variation, several aspects of otter diets important to understanding their ecological role have not been examined. For example, studies have not examined spatial variations in the otter diet, specifically the variation in diet from the headwaters downstream. Fish communities are known to vary longitudinally in stream systems; this gradient is expected to influence otter diets. Also, no study has identified depredated fishes beyond the taxonomic level of family. This limitation is particularly important for Ozark streams, because the family Centrarchidae contains several popular sport fish including: black bass (*Micropterus* spp.), Rock Bass (*Ambloplites rupestris*), crappie (*Pomoxis* spp.) and several other sunfish species (*Lepomis* spp.). Without accurate techniques to identify Centrarchidae beyond the family level, it is impossible to determine whether a scale

from a depredated fish is from a black bass or a sunfish.

The goal of this study was to obtain a better understanding of otter food habits in the Missouri Ozarks. The objectives were to:

- (1) compare seasonal differences in otter diets on two Ozark streams during the winter and summer seasons;
- (2) describe spatial variation in otter diets on these two streams;
- (3) quantify the fish component of the diet at the family level;
- (4) describe the specific Centrarchidae genera in otter diets, including age distributions; and
- (5) quantify the crayfish component of otter diets.

Study Area

We studied otter diets in two Ozark streams, Osage Fork River and Big Piney River. Both streams are in the Gasconade River watershed, which lies on the northern side of the Ozark drainage divide (Nigh and Schroeder 2002) entirely within the state of Missouri, USA. This region is characterized by deeply dissected sandstone, limestone, and dolomite hills. There is moderate to high relief near the rivers. The upland areas are primarily oak-hickory woodlands with some pine-oak woodland, and cleared agricultural land. The

streams of the region are influenced by numerous springs that contribute to a significant base flow. The rivers typically have low turbidity and well defined riffle-pool complexes.

Osage Fork River originates in Webster County and flows through Wright and Laclede counties before its confluence with the Gasconade River in Pulaski County. The reaches we sampled were all contained in Laclede County and included a reach from State Highway J to State Highway 5, State Highway 5 to State Highway B, and State Highway B to the Missouri Department of Conservation's (MDC) Drynob Access near State Highway 32 (Figure 1). In addition, we examined diets on three significant tributaries to Osage Fork River located in Laclede County, including: Mill Creek, North Cobb Creek, and Cobb Creek (Figure 1).

Big Piney River originates in Texas County and flows through Phelps and Pulaski counties before its confluence with the Gasconade River in Pulaski County. We examined otter diets on three reaches of the Big Piney, including U.S. Highway 63 to MDC's Dog's Bluff Access, U.S. Forest Service Slabtown Access to MDC's Ross Access, and U.S. Forest Service East Gate Access to U.S. Forest Service Road #1730 (Figure 1). In addition, we examined diets on three major tributaries in Texas County, including Indian Creek, Hog Creek, and West Piney Creek (Figure 1).

Materials and Methods

River Otter scats were collected from the Big Piney River and Osage Fork River systems during the winter (January–March) and summer (June–August) seasons of 2001 and 2002. To select sample sites we divided each stream, including major tributaries, into 16 km reaches and randomly chose four of these reaches for each river. Each of these 16 km reaches were then divided into equal 0.4 km segments, of which 10 were selected for sampling for each reach. This yielded 4 km of streamside to sample for each reach of stream, and thus 16 km for each stream. Each reach of stream was visited three times during each season, approximately two weeks apart. With the exception of tributary reaches, all study areas were accessed with a canoe. Within the 0.4 km segments, both banks of the river were searched for otter scats and latrines. All latrines located within the study segments were marked with flagging and assigned a unique identification number. All otter scats were removed on the first visit of the season to assure that all scats recovered from two subsequent visits during the season were deposited between visits. During the next two visits, all otter scats found in the segments were collected and individually stored in plastic bags for later analysis.

Scats were dried in a food dehydrator prior to analysis. Dried scats are much easier to examine because small pieces, such as fish scales, do not adhere together. The scat material was then carefully sorted, and

potentially diagnostic materials retained. Diagnostic materials consisted primarily of fish scales, bones, feathers, crayfish cheala, and hair. Presence or absence of these prey items was recorded. The frequency of occurrence (% of scats containing a prey item) was determined. This approach was used to make data comparable to other food habit studies (e.g., Lagler and Ostenson 1942; Wilson 1954; Ryder 1955; Hamilton 1961; Knudsen and Hale 1968; Grenfell 1974; Toweill 1974; Lauhachinda 1978; Gilbert and Nancekivell 1982; Reid et al. 1994). Scat analysis on captive European River Otters (*Lutra lutra*) showed frequency of occurrence to accurately represent diets and the relative importance of prey types (Erlinge 1968). Calculating percent by volume was not considered feasible due to the varying digestibility of food types. For example, crayfish have a relatively high proportion of indigestible material (i.e. chitin) compared to a fish of the same mass and would be over-represented in a scat sample (Pierce 1979).

Fish scales recovered from scats were pressed on acetate plates and the impressions were viewed with a microfiche reader. Scales were aged by annuli counts and identified to the family level using established keys (Lagler 1947; Oats et al. 1993; Daniels 1996). Scales identified as the family Catostomidae (suckers) may have included the carp species of the family Cyprinidae (minnows) because carp scales are indistinguishable from Catostomidae (Lagler 1947; Oats et al. 1993; Daniels 1996). Similarly, the western mosquitofish (*Gambusia affinis*) of the family Poeciliidae (live-bearers) are combined with Fundulidae (top-minnows and killfishes). Ictaluridae (catfish) and Cottidae (sculpins), while present in rivers in low densities (Pflieger 1997), both lack scales and cannot be separated. Therefore, we assumed that the presence of fish bones in a scat sample without any scales indicated the presence of one of these two families. These two families are referred to collectively as "scaleless fish". Several measurements were taken from lateral line scales from the family Centrarchidae and used in a linear discriminant analysis model to identify specific centrarchid genera (Roberts et al. 2007).

Results

Otter diets contained fish, crayfish, amphibians, reptiles, mammals and birds. Crayfish and fish were the predominant prey items. A total of 777 samples was collected during the winter seasons and 1137 samples were collected during the summer seasons from the Big Piney River. A total of 1443 samples was collected during the winter seasons and 1393 samples were collected during the summer seasons from the Osage Fork River. Fish were more frequently found in the winter. Fish remains were found in 88% of all winter season Big Piney samples and in 84.3% of all winter season Osage Fork samples (Table 1). During the sum-

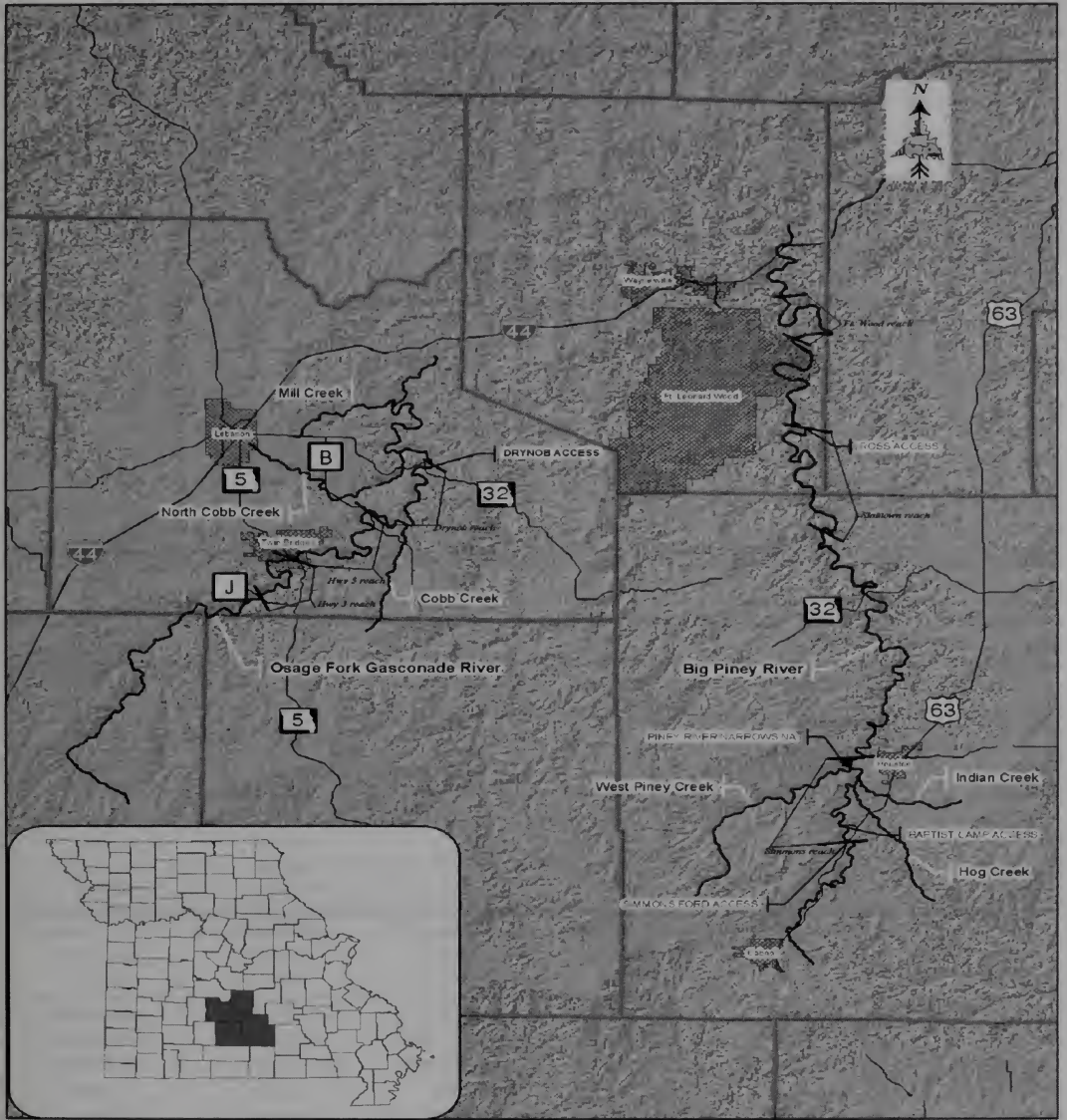


FIGURE 1. Map of study area.

mer seasons, frequency of occurrence of fish remains dropped to 14.6% for Big Piney River and 14.2% for Osage Fork River (Table 2).

On the Big Piney River, frequency of occurrence of fish remains during the winter seasons varied between reaches from 84.7% to 94.34% and showed no distinct spatial variation between upstream and downstream reaches (Table 1). Frequency of occurrence of fish remains in winter samples from the Osage Fork varied between reaches from 81.26% to 93.96% and decreased from the upstream to downstream reaches (Table 1). During the summer seasons, frequency of occurrence of fish remains varied between reaches from 12.7%

to 21.74% on the Big Piney River and from 11.22% to 18.25% on the Osage Fork River, with no distinct longitudinal patterns (Table 2).

Of the several fish families identified from scales (Tables 3 and 4), Centrarchidae occurred more frequently than all other families combined during both seasons on both rivers. There was, however, no discernable spatial pattern between reaches (Tables 3 and 4). Centrarchidae did occur in slightly higher frequencies in samples from the Big Piney River during both seasons. Within the family Centrarchidae, the genus *Lepomis* occurred more frequently than *Micropterus* or *Ambloplites* in both rivers regardless of season

TABLE 1. Frequency of occurrence of prey items from otter scat during winter seasons on Big Piney River (B.P.) and Osage Fork River (O.S.).

Taxa	B.P.-Tributaries (n = 243) % (n)	B.P.-Simmons (n = 213) % (n)	B.P.-Slabtown (n = 268) % (n)	B.P.-Ft. Wood (n = 53) % (n)	B.P. Totals (n = 777) % (n)
Fish	88.5 (215)	90.1 (192)	84.7 (227)	94.3 (50)	88.0 (684)
Crayfish	81.5 (198)	60.6 (129)	82.8 (222)	54.7 (29)	74.4 (578)
Amphibian	10.3 (25)	11.3 (24)	9.7 (26)	9.4 (5)	10.3 (680)
Bird	0.4 (1)	0.00 (0)	0.0 (0)	0.0 (0)	0.1 (1)
Mammal	0.00 (0)	0.00 (0)	0.4 (1)	0.0 (0)	0.1 (1)
Reptile	0.4 (1)	0.00 (0)	0.0 (0)	0.0 (0)	0.1 (1)

Taxa	O.F.-Tributaries (n = 149) % (n)	O.F.-Highway J (n = 420) % (n)	O.F.-Highway 5 (n = 255) % (n)	O.F.-Drynob (n = 619) % (n)	O.F. Totals (n = 1443) % (n)
Fish	94.0 (140)	85.7 (360)	83.9 (214)	81.3 (503)	84.3 (1217)
Crayfish	94.0 (140)	83.1 (349)	93.7 (239)	96.1 (595)	91.7 (1323)
Amphibian	27.5 (41)	17.1 (72)	8.6 (22)	9.5 (59)	13.4 (194)
Bird	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Mammal	0.0 (0)	0.0 (0)	0.8 (2)	0.0 (0)	0.1 (2)
Reptile	0.0 (0)	0.0 (0)	0.0 (0)	0.2 (1)	0.1 (1)

TABLE 2. Frequency of occurrence of prey items from otter scat during summer seasons on Big Piney River (B.P.) and Osage Fork River (O.S.).

Taxa	B.P.-Tributaries (n = 427) % (n)	B.P.-Simmons (n = 317) % (n)	B.P.-Slabtown (n = 370) % (n)	B.P.-Ft. Wood (n = 23) % (n)	B.P. Totals (n = 1137) % (n)
Fish	13.8 (59)	17.4 (55)	12.7 (47)	21.7 (5)	14.6 (166)
Crayfish	99.5 (425)	98.7 (313)	99.2 (367)	100.0 (23)	99.2 (1128)
Amphibian	13.6 (58)	13.9 (44)	9.7 (36)	21.7 (5)	12.6 (143)
Bird	0.0 (0)	0.3 (1)	0.5 (2)	0.0 (0)	0.3 (3)
Mammal	2.3 (10)	0.6 (2)	0.3 (1)	0.0 (0)	1.1 (13)
Reptile	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

Taxa	O.F.-Tributaries (n = 490) % (n)	O.F.-Highway J (n = 367) % (n)	O.F.-Highway 5 (n = 126) % (n)	O.F.-Drynob (n = 410) % (n)	O.F. Totals (n = 1393) % (n)
Fish	15.7 (77)	14.2 (52)	18.3 (23)	11.2 (46)	14.2 (198)
Crayfish	100.0 (490)	99.7 (366)	100.0 (126)	99.8 (409)	99.9 (1391)
Amphibian	21.2 (104)	11.7 (43)	15.9 (20)	7.6 (31)	14.2 (198)
Bird	0.2 (1)	1.9 (7)	0.0 (0)	0.2 (1)	0.7 (9)
Mammal	1.6 (8)	1.6 (6)	4.8 (6)	0.7 (3)	1.7 (23)
Reptile	0.4 (2)	0.0 (0)	0.0 (0)	0.2 (1)	0.2 (3)

(Tables 5 and 6). *Micropterus* and *Ambloplites* occurred in similar frequencies on both rivers. No distinct spatial pattern was observed for any genus.

The mean age of *Ambloplites* was consistently older than either *Lepomis* or *Micropterus* (Table 7). Of the latter two genera, *Micropterus* consistently had the youngest mean age. During the winter, scales from older centrarchids were more common in scats collected from the downstream reaches of the river (Figure 2). During the summer, the small sample size of centrarchids precluded any comparison (Figure 3).

During the winter seasons, both the family Percidae and Fundulidae occurred most frequently in the scats from tributary reaches of both rivers. However, dur-

ing the summer seasons, no patterns were observed. While Catostomidae occurred in only 2.4% of all the summer samples, their frequency of occurrence increased during the winter seasons to 7.21% and 4.09% of all Big Piney and Osage Fork samples, respectively. The Sciaenidae, Clupeidae, and Ictaluridae and Cottidae always occurred at frequencies less than 5%, regardless of season or river.

Crayfish remains were recovered in 74.4% of all winter season Big Piney samples and 91.7% of all winter season Osage Fork samples (Table 1). The frequency of occurrence of crayfish during the summer seasons increased to 99.21% and 99.9% for all samples from the Big Piney River and Osage Fork

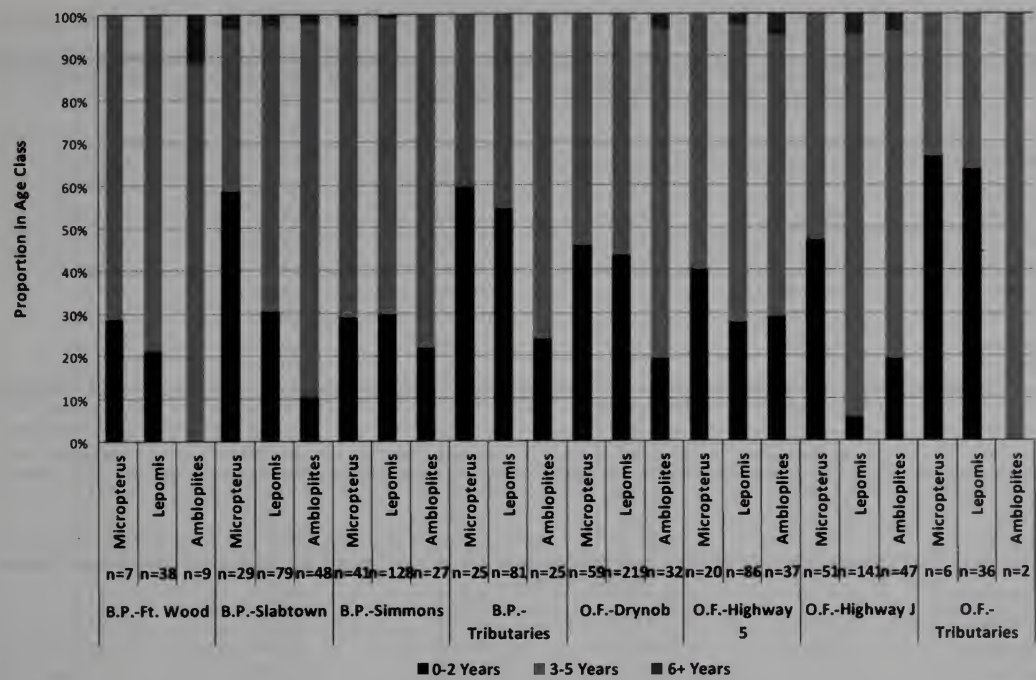


FIGURE 2. Age distributions of Centrarchidae genera in otter scats collected from the Big Piney River (B.P.) and Osage Fork River (O.S.) reaches during the winter seasons.

TABLE 3. Frequency of occurrence of families of fish recovered from the scats of otters during the winter seasons on Big Piney River (B.P.) and Osage Fork River (O.S.).

Family	B.P.-Tributaries n = 243 % (n)	B.P.-Simmons n = 213 % (n)	B.P.-Slabtown n = 268 % (n)	B.P.-Ft. Wood n = 53 % (n)	B.P. Totals n = 777 % (n)
Centrarchidae	68.3 (166)	81.7 (174)	65.7 (176)	84.9 (45)	72.2 (561)
Percidae	27.2 (66)	14.6 (31)	12.3 (33)	5.7 (3)	17.1 (133)
Cyprinidae	16.9 (41)	30.1 (64)	28.7 (77)	28.3 (15)	25.4 (197)
Fundulidae	21.0 (51)	7.5 (16)	7.1 (19)	1.9 (1)	11.2 (87)
Catostomidae	2.1 (5)	10.8 (23)	9.7 (26)	3.8 (2)	7.2 (56)
Sciaenidae	0.0 (0)	0.5 (1)	1.5 (4)	0.0 (0)	0.6 (5)
Clupeidae	0.0 (0)	0.0 (0)	0.0 (0)	3.8 (2)	0.3 (2)
Scaleless	1.2 (3)	0.9 (2)	1.1 (3)	0.0 (0)	1.0 (8)
Unknown	1.65 (4)	1.4 (3)	0.0 (0)	1.9 (1)	1.0 (8)

	O.F.-Tributaries n = 149 % (n)	O.F.-Highway J n = 420 % (n)	O.F.-Highway 5 n = 255 % (n)	O.F. Drynob n = 619 % (n)	O.F. Totals n = 1443 % (n)
Centrarchidae	52.4 (78)	67.9 (285)	62.0 (158)	65.1 (403)	64.0 (924)
Percidae	65.1 (97)	19.1 (80)	29.8 (76)	34.7 (215)	32.4 (468)
Cyprinidae	12.8 (19)	17.1 (72)	9.4 (24)	9.2 (57)	11.9 (172)
Fundulidae	38.3 (57)	11.7 (49)	5.5 (14)	4.7 (29)	10.3 (149)
Catostomidae	4.7 (7)	5.4 (23)	4.3 (11)	2.9 (18)	4.1 (59)
Sciaenidae	0.0 (0)	0.2 (1)	2.4 (6)	2.6 (16)	1.6 (23)
Clupeidae	0.0 (0)	0.5 (2)	0.0 (0)	0.2 (1)	0.2 (3)
Scaleless	0.0 (0)	4.1 (17)	3.9 (10)	1.9 (12)	2.7 (39)
Unknown	4.0 (6)	3.3 (14)	1.6 (4)	1.8 (11)	2.4 (35)

TABLE 4. Frequency of occurrence of families of fish recovered from the scats of otters during the summer seasons on Big Piney River (B.P) and Osage Fork River (O.S.).

Family	B.P.-Tributaries <i>n</i> = 427 % (<i>n</i>)	B.P.-Simmons <i>n</i> = 317 % (<i>n</i>)	B.P.-Slabtown <i>n</i> = 370 % (<i>n</i>)	B.P.-Ft. Wood <i>n</i> = 23 % (<i>n</i>)	B.P. Totals <i>n</i> = 1137 % (<i>n</i>)
Centrarchidae	8.0 (34)	12.3 (39)	7.6 (28)	21.7 (5)	9.3 (106)
Percidae	0.2 (1)	1.3 (4)	1.1 (4)	0.0 (0)	0.8 (9)
Cyprinidae	0.9 (4)	1.9 (6)	0.0 (0)	0.0 (0)	0.9 (10)
Fundulidae	1.2 (5)	0.0 (0)	0.5 (2)	4.4 (1)	0.7 (8)
Catostomidae	0.0 (0)	0.0 (0)	0.5 (2)	0.0 (0)	0.2 (2)
Sciaenidae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Clupeidae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Scaleless	2.3 (10)	3.2 (10)	1.6 (6)	0.0 (0)	2.3 (26)
Unknown	2.1 (9)	0.3 (1)	1.6 (6)	0.0 (0)	1.4 (16)
	O.F.-Tributaries <i>n</i> = 490 % (<i>n</i>)	O.F.-Highway J <i>n</i> = 367 % (<i>n</i>)	O.F.-Highway 5 <i>n</i> = 126 % (<i>n</i>)	O.F. Drynob <i>n</i> = 410 % (<i>n</i>)	O.F. Totals <i>n</i> = 1393 % (<i>n</i>)
Centrarchidae	8.2 (40)	9.0 (33)	10.3 (13)	3.9 (16)	7.3 (102)
Percidae	4.3 (21)	1.6 (6)	0.8 (1)	1.5 (6)	2.4 (34)
Cyprinidae	0.8 (4)	0.5 (2)	1.6 (2)	0.7 (3)	0.8 (11)
Fundulidae	0.2 (1)	0.5 (2)	4.0 (5)	0.7 (3)	0.8 (11)
Catostomidae	0.8 (4)	0.0 (0)	0.0 (0)	0.0 (0)	0.3 (4)
Sciaenidae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Clupeidae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Scaleless	2.5 (12)	2.5 (9)	2.4 (3)	4.2 (17)	2.9 (41)
Unknown	1.8 (9)	1.4 (5)	1.6 (2)	0.5 (2)	1.3 (18)

TABLE 5. Frequency of occurrence of Centrarchidae genera in otter scats collected during the winter seasons on Big Piney River (BP) and Osage Fork River (O.S.).

Genus	B.P.-Tributaries <i>n</i> = 243 % (<i>n</i>)	B.P.-Simmons <i>n</i> = 213 % (<i>n</i>)	B.P.-Slabtown <i>n</i> = 268 % (<i>n</i>)	B.P.-Ft. Wood <i>n</i> = 53 % (<i>n</i>)	B.P.-Totals <i>n</i> = 777 % (<i>n</i>)
<i>Micropterus</i>	9.5 (23)	17.8 (38)	10.1 (27)	13.2 (7)	12.2 (95)
<i>Lepomis</i>	28.8 (70)	48.4 (103)	25.8 (69)	56.6 (30)	35.0 (272)
<i>Ambloplites</i>	10.3 (25)	11.3 (24)	16.4 (44)	17.0 (9)	13.1 (102)
Indiscernible	46.5 (113)	44.6 (95)	40.7 (109)	47.2 (25)	44.0 (342)
	O.F.-Tributaries <i>n</i> = 149 % (<i>n</i>)	O.F.-Highway J <i>n</i> = 420 % (<i>n</i>)	O.F.-Highway 5 <i>n</i> = 255 % (<i>n</i>)	O.F.-Drynob <i>n</i> = 619 % (<i>n</i>)	O.F.-Totals <i>n</i> = 1443 % (<i>n</i>)
<i>Micropterus</i>	4.0 (6)	11.4 (48)	7.5 (19)	9.2 (57)	9.0 (130)
<i>Lepomis</i>	19.5 (29)	39.5 (166)	27.1 (69)	29.7 (184)	31.1 (448)
<i>Ambloplites</i>	1.3 (2)	11.0 (46)	13.7 (35)	4.9 (30)	7.8 (113)
Indiscernible	38.3 (57)	44.5 (187)	37.7 (96)	46.2 (286)	43.4 (626)

River respectively (Table 2). No distinct spatial pattern was observed between reaches for either river.

Mammals and birds both occurred at low frequencies (< 5%) and occurred most commonly during the summer seasons (Tables 1 and 2). Both occurred most frequently in the upstream reaches of the rivers. All mammals encountered were Muskrats (*Ondatra zibethicus*) with the exception of one Beaver (*Castor canadensis*) that occurred on a tributary reach of the Big Piney River during the winter season. The birds en-

countered were few in number and not identified.

Amphibians were frequently encountered in both seasons; however, amphibians were slightly more common during the summer season (Tables 1 and 2). With the exception of the Fort Leonard Wood reach of the Big Piney River during the summer seasons, amphibians were more common in the upstream reaches of the river. Reptiles were rarely encountered and occurred in < 0.5% of samples. The reptiles encountered consisted of four snakes and one turtle.

TABLE 6. Frequency of occurrence of Centrarchidae genera in otter scats collected during the summer seasons on Big Piney River (B.P.) and Osage Fork River (O.S.).

Genus	B.P.-Tributaries <i>n</i> = 427 % (<i>n</i>)	B.P.-Simmons <i>n</i> = 317 % (<i>n</i>)	B.P.-Slabtown <i>n</i> = 370 % (<i>n</i>)	B.P.-Ft. Wood <i>n</i> = 23 % (<i>n</i>)	B.P.-Totals <i>n</i> = 1137 % (<i>n</i>)
<i>Micropterus</i>	0.0 (0)	0.6 (2)	0.0 (0)	0.0 (0)	0.2 (2)
<i>Lepomis</i>	0.7 (3)	3.2 (10)	1.4 (5)	4.4 (1)	1.7 (19)
<i>Ambloplites</i>	0.5 (2)	0.3 (1)	0.3 (1)	0.0 (0)	0.4 (4)
Indiscernible	7.5 (32)	11.0 (35)	6.5 (24)	21.7 (5)	8.4 (96)

	O.F.-Tributaries <i>n</i> = 490 % (<i>n</i>)	O.F.-Highway J <i>n</i> = 367 % (<i>n</i>)	O.F.-Highway 5 <i>n</i> = 126 % (<i>n</i>)	O.F.-Drynob <i>n</i> = 410 % (<i>n</i>)	O.F.-Totals <i>n</i> = 1393 % (<i>n</i>)
<i>Micropterus</i>	0.0 (0)	0.0 (0)	0.0 (0)	0.2 (1)	0.1 (1)
<i>Lepomis</i>	0.6 (3)	1.4 (5)	0.0 (0)	0.2 (1)	0.7 (9)
<i>Ambloplites</i>	0.0 (0)	0.8 (3)	0.0 (0)	0.0 (0)	0.2 (3)
Indiscernible	7.6 (37)	7.4 (27)	10.3 (13)	3.9 (16)	6.7 (93)

TABLE 7. Mean age of Centrarchidae genera by river and season

	River and Season			
	Big Piney Winter	Osage Fork Winter	Big Piney Summer	Osage Fork Summer
<i>Micropterus</i>	2.6 (<i>n</i> = 103)	2.5 (<i>n</i> = 136)	2 (<i>n</i> = 2)	3 (<i>n</i> = 1)
<i>Lepomis</i>	2.9 (<i>n</i> = 326)	2.7 (<i>n</i> = 554)	2.9 (<i>n</i> = 20)	3.2 (<i>n</i> = 9)
<i>Ambloplites</i>	3.3 (<i>n</i> = 109)	3.3 (<i>n</i> = 118)	3.25 (<i>n</i> = 4)	3.33 (<i>n</i> = 3)

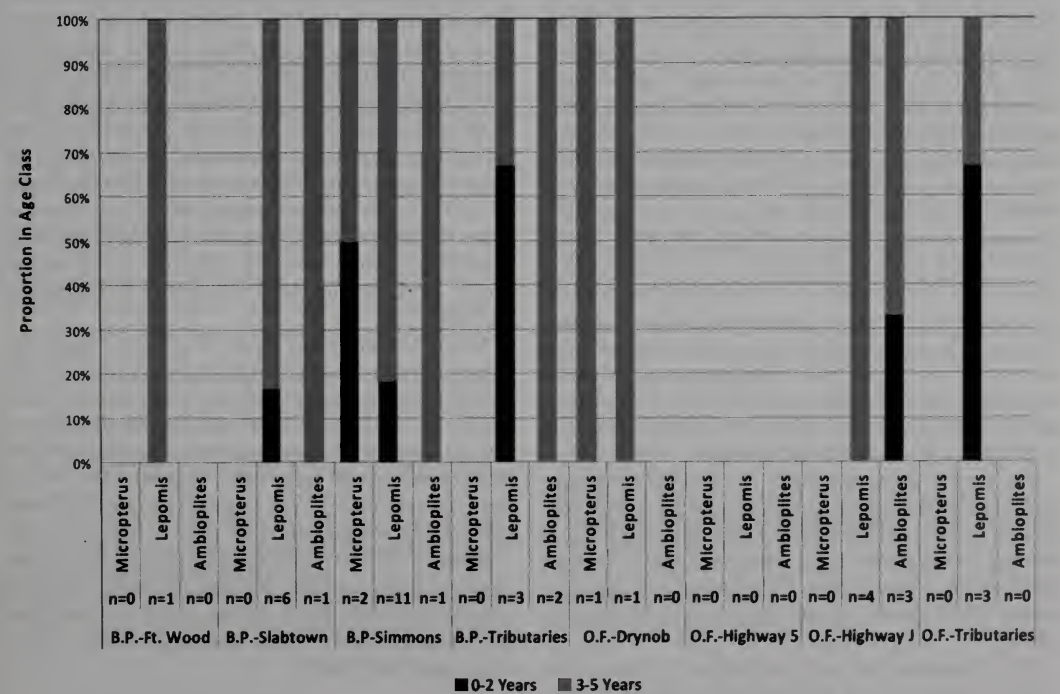


FIGURE 3. Age distributions of Centrarchidae genera in otter scats collected from the Big Piney River (B.P.) and Osage Fork River (O.S.) reaches during the summer seasons.

Discussion

During the summer, crayfish compose the majority of the diet, while during the winter the frequency of fish surpassed crayfish on the Big Piney River and was comparable to the frequency of crayfish on the Osage Fork River. This seasonal shift in otter diet has been observed in Illinois (Anderson and Woolf 1987). Crayfish, while not absent, are less active and available during the winter seasons (Muck et al. 2002). The decreased availability of crayfish combined with the tendency of fish to be less active and slower during the winter (Wardle 1980) may be the reason that increased fish predation is observed during the winter season.

The importance of fish in diets of Ozark otters is similar to other studies conducted during winter seasons spanning five decades (Lagler and Ostenson 1942; Wilson 1954; Ryder 1955; Hamilton 1961; Sheldon and Toll 1964; Knudsen and Hale 1968; Grenfell 1974; Toweill 1974; Lauhachinda 1978; Gilbert and Nancekivell 1982; Reid et al. 1994). Surprisingly, there was little spatial variation in prey taxa occurrence for either river. Crayfish were a more common diet item in the upper reaches of the Osage Fork River, but this trend was not observed on the Big Piney River. Larger fish are less common in upper reaches of streams and probably account for the high frequency of crayfish in otter diets from these reaches (Schlosser 1987).

The family Centrarchidae was the most frequently occurring family in the diet during both seasons in both rivers. Estimates of fish communities on Courtois Creek, an Ozark stream assumed to be representative of typical small to medium-sized Ozark streams had approximately 32% more standing crop of Catostomidae than Centrarchidae (Fajen 1975). Despite this, Catostomidae occurred in the diet much less frequently than Centrarchidae. Other studies have concluded that centrarchid fish are preyed on disproportionately because centrarchids occur in areas where otters forage, such as the littoral zone (Greer 1955; Ryder 1955; Sheldon and Toll 1964). Both Smallmouth Bass and Rock Bass avoid open water in favor of cover (rootwads, log complexes, logs) occurring near the shoreline (Probst et al. 1984). The findings of this study also suggest that otters prey disproportionately on certain centrarchid species because of the latter's tendency to inhabit areas where otters forage.

The high relative frequency of *Lepomis* compared to *Micropterus* and *Ambloplites* is likely a function of high relative densities of *Lepomis* species in Ozark streams. In Courtois Creek, there were approximately 887% more *Lepomis* than *Micropterus* and approximately 851% more *Lepomis* than *Ambloplites* (Fajen 1975).

Fish communities vary longitudinally (Schlosser 1987). However, very little spatial variation in diet was observed for most of the fish families, except Fundulidae and Percidae. During the winter seasons both families occurred more commonly in scats from

the upper reaches of the stream. Both of these families are composed of small fishes in Ozark streams. Darters (*Etheostoma* spp.) are the common Percidae found in these Ozark streams. Larger streams support a variety of habitat types that, in turn, can support an increased species diversity and species richness (Schlosser 1987). Lower order reaches of rivers have fish communities composed primarily of small fishes. The spatial trends observed for Fundulidae and Percidae in otter diets are probably a function of the longitudinal gradient in fish communities.

The frequencies of crayfish recorded during the summer seasons were higher than in any previous study conducted on river systems (Lagler and Ostenson 1942; Wilson 1954; Ryder 1955; Hamilton 1961; Knudsen and Hale 1968; Grenfell 1974; Toweill 1974; Gilbert and Nancekivell 1982; Reid et al. 1994). The relatively high occurrences of crayfish are likely a result of the fact that the Missouri Ozarks have some of the highest densities of crayfish reported in the United States (DiStefano 1993). Crayfish are consumed during both the winter and summer seasons, although they occur in the otter diet much more frequently during the summer season. The two species of crayfish that inhabit the study area, *Orconectes punctimanus* and *Orconectes luteus*, do not burrow during the winter (Pflieger 1996); a life-history characteristic that results in these two species always being available for otters.

The frequencies of amphibians and reptiles in Ozark diets are similar to those reported in other regions (Lagler and Ostenson 1942; Wilson 1954; Ryder 1955; Hamilton 1961; Knudsen and Hale 1968; Toweill 1974; Lauhachinda 1978; Anderson and Woolf 1987). In the present study, one turtle was identified in a sample collected during the summer. Although otters were observed consuming a large terrapin in Florida (Stophlet 1947), with this one exception, no previous evidence of otter predation on turtles has been reported in otter diets, even in areas where turtles were abundant (Greer 1955; Grenfell 1974; Toweill 1974; Lauhachinda 1978).

Mammals and birds were encountered more frequently during the summer but never occurred at frequencies greater than 5% during either season. These results are similar to several previous studies (Wilson 1954; Greer 1955; Hamilton 1961; Sheldon and Toll 1964; Knudsen and Hale 1968; Grenfell 1974; Toweill 1974; Lauhachinda 1978). Higher frequencies of mammal remains were found in the diets of otters in Alberta, Canada (Gilbert and Nancekivell 1982). The low frequencies of mammal remains in Ozark otter diets suggest that birds and mammals are not an important prey item for River Otters and are probably utilized only opportunistically.

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Contaminant Levels in Eggs of American White Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, North Dakota

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American White Pelicans (*Pelecanus erythrorhynchos*) are colonial nesters, making them susceptible to site-specific mortality factors. One of the largest known breeding colonies is at Chase Lake National Wildlife Refuge in North Dakota. In 2004, this colony suffered total reproductive failure. In 2005, we collected abandoned eggs from this colony to test for environmental contaminants. Nine eggs were analyzed for 28 organochlorine pesticides, total polychlorinated biphenyls, and 26 inorganic elements. Based on concentrations in this sample of eggs and levels linked to reproductive problems in birds, adult pelicans in the Chase Lake breeding colony are not at known risk from any of the environmental contaminants we measured.

Key Words: American White Pelicans, *Pelecanus erythrorhynchos*, eggs, organic contaminants, metals, Chase Lake National Wildlife Refuge, North Dakota.

American White Pelicans (*Pelecanus erythrorhynchos*, hereafter white pelicans) nest on the ground in colonies, often on remote islands. Because their breeding activities are spatially concentrated, they are vulnerable to site-specific mortality factors. Nearly half of the population breeds in a few colonies in the northern plains. One of the largest known nesting colonies is on Chase Lake National Wildlife Refuge (Sovada et al. 2005). In 2004, this colony suffered total reproductive failure following the mass exodus of breeding adults (Sovada et al. 2008). During the media storm precipitated by this event, numerous possible causes were proposed for the adult departures. Most of the suggestions were easily dismissed by a review of the available facts (Sovada et al. 2008), which suggested Coyote (*Canis latrans*) disturbance and a weather event were responsible. However, the attention provided impetus to examine some possibilities that, although highly unlikely, could not be entirely dismissed. Following the 2005 breeding season (another year in which extreme weather events severely reduced reproductive success [Sovada et al. 2008]), we salvaged eggs from the Chase Lake colony for contaminant testing.

White Pelicans eat mostly fish and other prey taken from shallow waters (Knopf and Evans 2004*). In the past, they have suffered direct effects from agricultural runoff (e.g., toxaphene poisoning [Johnson 1966]) and effects of bioaccumulated organic contaminants (e.g., eggshell thinning from DDT [Anderson et al. 1969; Anderson and Hickey 1972; Knopf and Street 1974]). Restrictions on use of some chemicals have

reversed specific contaminant impacts (e.g., Bugden and Evans 1997), but white pelicans, like other piscivorous waterbirds, are still susceptible to a number of environmental contaminants. Several contaminants occur at different levels in male and female white pelicans, presumably because females can excrete organochlorines and some trace elements into their eggs prior to laying (Donaldson and Braune 1999). Thus, we tested contaminant levels in white pelican eggs as a surrogate for exposure levels in adult white pelicans.

Methods

During 11 to 18 August 2005, we collected 10 abandoned eggs, each from a different nest site, on the white pelican breeding colony at Chase Lake National Wildlife Refuge in Stutsman County, North Dakota. The salvaged eggs were laid during May or June 2005. Nine of the eggs were deemed suitable for analysis (one was cracked). In the laboratory, eggs were weighed on an electronic pan balance (0.01 g), measured (length [0.01 mm] and width [0.01 mm, averaged 2 measurements taken at widest point]) with calipers, and the contents emptied into chemically clean glass jars. Egg samples were then frozen (<-30° C) until chemically analyzed.

These nine eggs were analyzed for 28 organochlorine pesticides and total polychlorinated biphenyls (PCBs) by the Geochemical & Environmental Research Group (GERG), Texas A&M University, College Station, Texas. The same eggs were analyzed for 26 trace and other inorganic elements by the Trace Element

Research Laboratory (TERL), Texas A&M University, College Station, Texas.

Eggs were analyzed for the following organochlorine contaminants: aldrin; α -, β -, γ - and δ -benzene hexachloride (BHC); α - and γ -chlordane; chlorpyrifos; *cis*-nonachlor; *trans*-nonachlor; dieldrin; endosulfan II; endrin; heptachlor; heptachlor epoxide (HE); hexachlorobenzene (HCB); mirex; oxychlordane; 1,1-dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl)ethane [*o,p'*DDD]; 1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethene [*o,p'*-DDE]; 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl) ethane [*o,p'*-DDT]; *p,p'*-DDD; *p,p'*-DDE; *p,p'*-DDT; pentachloro-anisole; toxaphene; and 1,2,3,4- and 1,2,4,5-tetrachlorobenzene. Average levels of detection were 0.0008 $\mu\text{g/g}$ wet weight for all organics except total PCBs and toxaphene, which had detection limits of 0.016 $\mu\text{g/g}$ wet weight. For the above organic chemicals, tissues were homogenized and extracted with Na_2SO_4 and methylene chloride, and then purified by silica/alumina column chromatography and high performance liquid chromatography (MacLeod et al. 1985; Wade et al. 1988, Brooks et al. 1989). Quantitative analyses were performed by capillary gas chromatography with an electron capture detector for pesticides and PCBs.

Analyses were conducted for 21 inorganic elements, with detection limits (in $\mu\text{g/g}$ dry weight) given parenthetically as follows: aluminum (5), arsenic (0.1), boron (1), barium (0.1), beryllium (0.05), cadmium (0.01), chromium (0.5), cobalt (0.5), copper (0.5), iron (1), magnesium (1), manganese (0.2), mercury (0.002), molybdenum (1), nickel (0.5), lead (0.05), selenium (0.1), strontium (0.05), titanium (0.5), vanadium (1), and zinc (0.5). Also analyzed were calcium (2), potassium (24), sodium (191), phosphorus (5), and sulfur (10).

For the inorganic analyses, tissue samples were homogenized and wet digested in the presence of nitric acid. Inductively coupled argon plasma spectrophotometry was used for all elements, except for arsenic, cadmium, lead, mercury, and selenium. Arsenic, cadmium, lead, and selenium were analyzed by inductively coupled plasma-mass spectroscopy and mercury by trapping on a gold column followed by atomic absorption.

For quality control purposes, each laboratory ran one blank, duplicate, and spike with the samples. Certified reference material was also used by each laboratory and one sample was confirmed by gas chromatography mass spectrometry. Concentrations were not corrected for percent recovery. The blanks, duplicates, and spikes met the respective GERG and TERL quality assurance standards. Concentrations of inorganic elements are reported on a dry weight basis. Organic contaminant concentrations were adjusted to account for moisture lost during incubation (Stickel et al. 1973) and after the nests were abandoned. The moisture correction factor for each egg was the total egg weight

divided by the egg volume. Egg volume was estimated by the equation from Hoyt (1979): $\text{Volume} = 0.51 \cdot \text{LB}^2$, where L is egg length and B is egg width (maximum diameter). All organic contaminant concentrations are expressed on a wet weight basis in tables and text. Average moisture and lipid content of the eggs are provided as percentages.

Results

Three organic chemicals, chlorpyrifos, δ -BHC, and toxaphene, were not detected in our sample of white pelican eggs. Aldrin, α - and β -BHC, and γ -chlordane were each detected in <50% of samples (Table 1) and had maximum concentrations of $\leq 0.002 \mu\text{g/g}$ wet weight. Of the remaining 23 organic chemicals all had geometric mean concentrations $< 0.01 \mu\text{g/g}$ wet weight except for total PCBs (0.35 $\mu\text{g/g}$), *p,p'*DDD ($< 0.02 \mu\text{g/g}$), *p,p'*DDE (0.08 $\mu\text{g/g}$), and dieldrin (0.01 $\mu\text{g/g}$) (Table 1). Moisture and lipid content of the eggs averaged 79.0% and 4.4%, respectively.

Aluminum, boron, beryllium, cadmium, chromium, cobalt, molybdenum, nickel, titanium, and vanadium were not detected in our sample of white pelican eggs. Lead was detected in only 1 egg, which contained $< 0.06 \mu\text{g/g}$ dry weight (Table 2). All of the remaining 15 elements were detected in all eggs (Table 2). Arsenic, mercury and selenium, which are of special interest because they can cause physiological problems in birds, had geometric mean concentrations of 0.28, 0.69, and 2.06 $\mu\text{g/g}$ dry weight, respectively.

Discussion

Neither organic nor inorganic chemicals in white pelican eggs from the Chase Lake National Wildlife Refuge were at concentrations considered to be problematic for the health of the birds. For three organic chemicals that have been linked to reproductive problems, levels of concern reported for wild bird eggs are $> 10 \mu\text{g/g}$ wet weight for PCBs (Hoffman et al. 1996; Custer et al. 2003), $> 3 \mu\text{g/g}$ wet weight for *p,p'*DDE (Blus et al. 1974), and $> 9 \mu\text{g/g}$ wet weight for dieldrin (Peakall 1996). Geometric mean concentrations for these three contaminants in our samples were much lower: $< 0.5 \mu\text{g/g}$ for PCBs, $< 0.1 \mu\text{g/g}$ for *p,p'*DDE, and < 0.1 for dieldrin. Compared to other locations, concentrations of *p,p'*DDE at Chase Lake National Wildlife Refuge were lower than concentrations previously documented in white pelicans in California and Nevada (Boellstorff et al. 1985; Wiemeyer et al. 2005). Dieldrin and PCB concentrations were similar among these three studies and were low. Of the trace elements, arsenic, lead, mercury, and selenium can be problematic in wild birds, but they were at low concentrations in our sample of white pelican eggs. Only one egg had detectable concentrations of lead. Levels of concern in eggs for the other three elements are $> 3 \mu\text{g/g}$ dry weight for arsenic (Seiler et al. 2003*), $> 2 \mu\text{g/g}$ dry weight for mercury (Thompson 1996) and $> 12 \mu\text{g/g}$ dry weight

TABLE 1. Concentrations of organic contaminants in eggs ($n = 9$) of American White Pelicans nesting at Chase Lake National Wildlife Refuge, North Dakota, in 2005.

Analyte	Geometric mean ($\mu\text{g/g}$ wet wt.)	95% confidence interval	Range ^b
Aldrin	— ^a		7ND–0.00169
α -BHC	—		8ND–0.000677
β -BHC	—		6ND–0.00164
γ -BHC	0.0009	0.0005–0.002	3ND–0.00344
α -chlordane	0.003	0.002–0.005	1ND–0.00697
γ -chlordane	—		5ND–0.00305
<i>o,p'</i> -DDD	0.002	0.001–0.003	1ND–0.00515
<i>o,p'</i> -DDE	0.001	0.0006–0.001	2ND–0.00193
<i>o,p'</i> -DDT	0.001	0.0008–0.002	1ND–0.00269
<i>o,p'</i> -DDD	0.015	0.011–0.019	0.00858–0.0306
<i>o,p'</i> -DDE	0.080	0.051–0.123	0.0293–0.215
<i>o,p'</i> -DDT	0.004	0.003–0.007	0.00174–0.012
Dieldrin	0.013	0.009–0.019	0.00528–0.0343
Endosulfan II	0.001	0.0006–0.002	4ND–0.00410
Endrin	0.002	0.001–0.003	0.000979–0.01009
HCB	0.001	0.0006–0.001	2ND–0.00305
Heptachlor	0.001	0.0007–0.002	2ND–0.00544
Heptachlor epoxide	0.003	0.002–0.003	0.00164–0.00385
Mirex	0.002	0.0007–0.003	3ND–0.00559
<i>cis</i> -nonachlor	0.003	0.001–0.005	1ND–0.00773
<i>trans</i> -nonachlor	0.006	0.005–0.009	0.00308–0.0139
Oxychlordane	0.003	0.003–0.005	0.00182–0.00694
PCBs (total)	0.354	0.298–0.419	0.243–0.496
Pentachloro-anisole	0.002	0.001–0.002	0.00101–0.00299
1,2,3,4-tetrachlorobenzene	0.001	0.0006–0.002	3ND–0.00511
1,2,4,5-tetrachlorobenzene	0.001	0.0006–0.002	3ND–0.00394

^a Geometric mean not calculated because <50% of samples with detectable concentrations.^b The number before 'ND' is the number of samples that had undetected values.TABLE 2. Element concentrations in eggs ($n = 9$) of American White Pelicans nesting at Chase Lake National Wildlife Refuge, North Dakota, in 2005.

Analyte	Geometric mean ($\mu\text{g/g}$, dry wt.)	95% confidence interval	Range
Arsenic	0.282	0.238–0.334	0.16–0.384
Barium	0.693	0.474–1.01	0.229–1.75
Calcium	6621	5007–8754	2940–10900
Copper	7.19	6.41–8.07	5.74–9.67
Iron	77.5	57.5–104	27.6–124
Lead	— ^a		8ND ^b –0.058
Magnesium	633.7	572–702	539–837
Manganese	0.709	0.527–0.953	0.344–1.73
Mercury	0.685	0.55–0.85	0.457–1.19
Phosphorus	4595	3839–5500	2530–6080
Potassium	6051	5347–6847	3780–7150
Selenium	2.06	1.79–2.37	1.53–3.26
Sodium	9401	8510–10384	6780–11000
Strontium	8.64	6.06–12.3	3.61–15.5
Sulfur	6787	6518–7068	6180–7680
Zinc	37.7	35.8–39.8	33.1–41.5

^a Geometric mean not calculated because <50% of samples with detectable concentrations.^b The number before 'ND' is the number of samples that had undetected values.

for selenium (Heinz 1996). None of the concentrations in our sample of white pelican eggs approached these levels of concern. Concentrations of mercury in pelican eggs at Chase Lake NWR were 2–4 times lower than in Nevada and California from areas with known

mercury contamination (Wiemeyer et al. 2007). Based on concentrations of organic and inorganic contaminants in this sample of eggs, adult white pelicans in this breeding colony are not at risk from any of the environmental contaminants measured.

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Nomadic Behavior of an Old and Formerly Territorial Eastern Coyote, *Canis latrans**

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We document the fate of a female Eastern Coyote on Cape Cod, Massachusetts that was a breeding resident of a ~30 km² territory for at least six years (1998–2004) and then became nomadic. Her behavior dramatically changed in January 2005, when she was located on six occasions sleeping under sheds and/or decks in highly residential neighborhoods at the southeastern edge of her range. On 11 March 2005 she localized in a small area (95% MCP range = 5.85 km²) at the northeastern edge of her old territory, where she remained until 1 March 2006. After briefly associating with other Coyotes (late-February 2006), her movement patterns changed again. She used a much larger area (~200 km²) until she was shot dead in February 2007. Tracking data indicated that she lived in localized areas during this nomadic period, possibly to avoid resident Coyote packs.

Key Words: Eastern Coyote, *Canis latrans*, nomadic movements, post-reproductive, suburban, transient, urbanized, Cape Cod, Massachusetts.

Eastern Coyotes (*Canis latrans*), like Wolves (*Canis lupus*), typically live in territorial social groups consisting of a breeding pair, their full-grown offspring (termed “beta” or “pack-associates”; usually one or two year-old individuals), and pups of the year (Gese et al. 1996; Mech et al. 1998; Patterson and Messier 2001; Way et al. 2002a; Mech and Boitani 2003b; Way 2003). In addition, lone individuals (termed “dispersers”, “nomads”, “transients”, or “floaters”) travel among resident packs and live in larger areas, in some instances traveling hundreds of miles from their birthplace (Mech and Boitani 2003b; Parker 1995; Way 2007). These nomadic individuals (both Eastern Coyotes and Wolves) are typically young (i.e., one-to two-year-old) animals that, in many cases, eventually establish territories as adults and cease their nomadic movements (Gese and Mech 1991; Harrison 1992; Mech et al. 1998; Mech and Boitani 2003a,b).

Little information currently exists on the behavior and movements of older canids (> 8-10 yr old) in part because they are rarely reported in the wild (Parker 1995: 85; Mech and Boitani 2003b; although see Dumond and Villard 2000 and Way and Strauss 2004). Mech and Boitani (2003a) noted that female Wolves generally reproduce until they die, but there is the possibility that they may become senescent if they survive long enough (i.e., 10–15 years). Detailed observations of individual canids over long periods of time are rarely reported because studies are typically short-term in duration, the animal dies at a younger age, and/or the animal’s radio-transmitter fails. However, D. Mech followed a female Wolf (#2473) in Minnesota from her early nomadic phase as a lone Wolf, through

several years as a territorial breeder, and then through her loss of that status (subsequently becoming nomadic again) following the death of her mate when a new male integrated into the pack and paired with her daughter (F. Harrington, perspersonal communication). These anecdotes provide a personal and intimate account of canid behavior that is rarely reported in more comprehensive studies (e.g., Harrison 1992; Gese et al. 1996; Way et al. 2002a, 2004).

In this paper, we report results obtained from over eight years of radio-telemetry data collection on a female Coyote on Cape Cod, Massachusetts was a breeding resident for at least six of these years and subsequently became a nomad or floater.

Methods

Study Area

The majority of the field work in this study was conducted in the urbanized town of Barnstable (155 km²), Cape Cod, Massachusetts, where human population density was 308 people/km² and housing density was 161/km². The entire Barnstable County (i.e., Cape Cod, 1024 km²), which includes the areas that the Coyote reported here (code-named “Casper”, ID #9804) used when nomadic (Figures 1 and 2), averaged 217 people/km² and 144 houses/km² (U. S. Census Bureau 2000 estimates). Cape Cod is a residential area interspersed with numerous small (5-10 ha) and several large (100–500 ha) conservation areas. Most of the neighborhoods are not fenced, allowing Coyotes to travel through these areas to access various portions of fragmented home ranges (Way et al. 2004).

*See Addenda following literature cited.

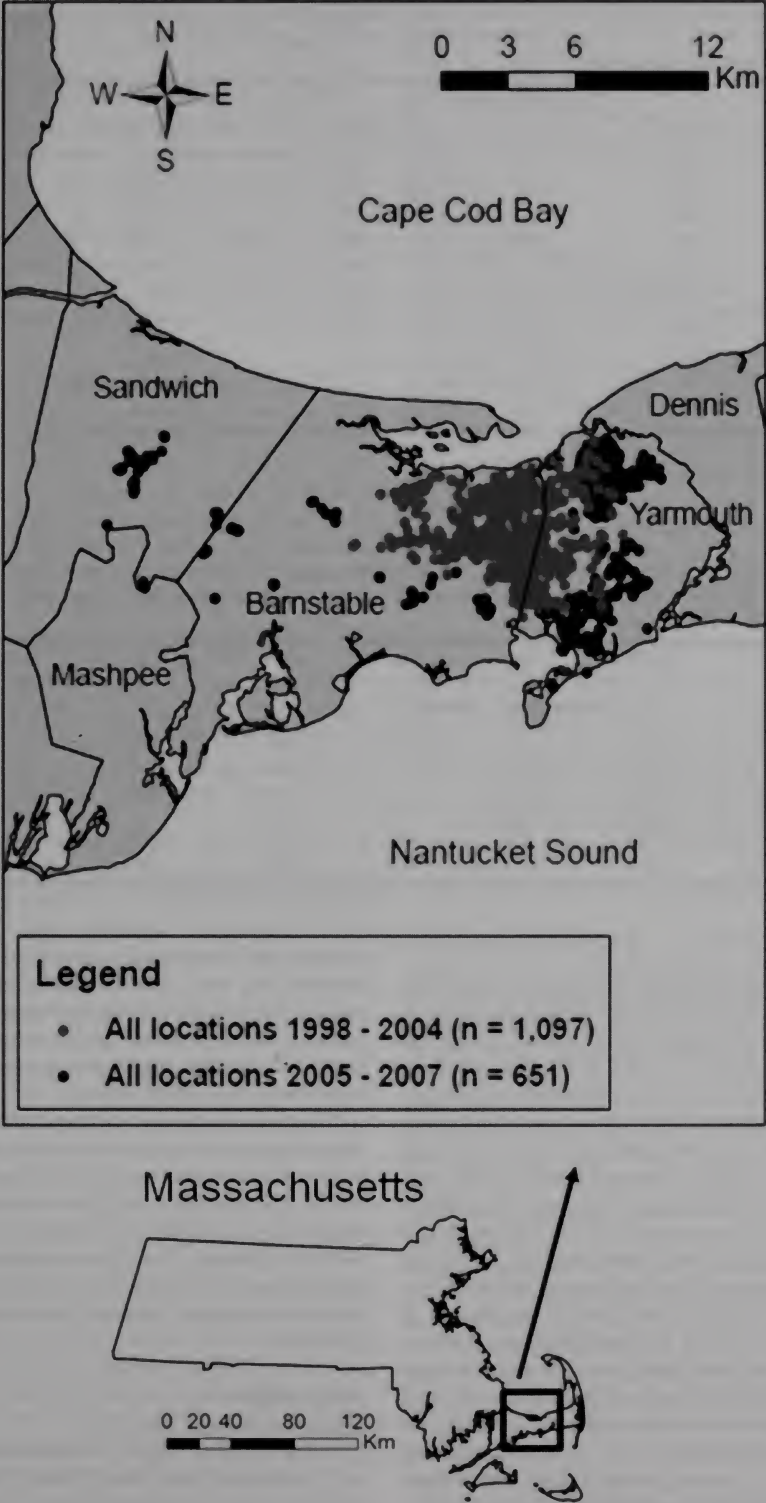


FIGURE 1. Study area focusing around the town of Barnstable on Cape Cod, Massachusetts, and all telemetry locations for Coyote #9804 (“Casper”) from 1998 through 2007.

TABLE 1. Number of telemetry locations and 95% and 100% Minimum Convex Polygon (MCP) home range estimates (in km²) for Eastern Coyote #9804 for each year of telemetry from 1999 through 2007. No locations were obtained during 2003 because her collar was non-functioning.

Year	Location attempts			95% MCP	100% MCP
	Total	S ¹	(% S ¹)		
1998	28	25	90	27.64	29.53
1999	410	401	98	32.79	51.06
2000	183	183	100	33.36	41.43
2001	260	260	100	31.04	41.47
2002	94	83	88	25.75	26.52
2003	0	0	n/a	n/a	n/a
2004	145	145	100	17.05	20.70
2005	207	202	98	10.60	15.04
2006	495	443	89	190.12	196.57
2007	11	3	27	199.38 ²	205.84 ²
Total	1833	1745	95		

¹S = successful radio-location

²Includes 2006/2007 data (446 locations)

TABLE 2. Percent overlap in 95% Minimum Convex Polygon home ranges between years for Coyote #9804. We captured her at the end of 1998 (hence low overlap with 1999–2004) and 2003 is not included because the Coyote carried a non-functioning radio-collar.

	1998	1999	2000	2001	2002	2004	2005	2006
1998	—	72.3	62.7	63.4	47.1	44.5	25.5	99.8
1999	61.0	—	86.2	82.7	68.5	51.9	6.5	100.0
2000	52.0	84.7	—	80.2	73.9	51.0	2.0	100.0
2001	56.4	87.3	86.2	—	76.5	100.0	0.5	100.0
2002	50.5	87.2	95.8	92.2	—	61.0	0.0	100.0
2004	72.1	99.8	99.8	95.6	92.2	—	0.0	100.0
2005	66.4	20.2	6.2	1.6	0.0	0.0	—	5.5
2006	14.5	17.2	17.5	16.3	13.5	9.0	5.5	—

Radio-telemetry

The Coyote was originally captured in a box trap (Way et al. 2002b) in November 1998 in the town of Barnstable. She was a large, robust 2.5 or 3.5 year-old female who weighed 23.2 kg and was 1.48 meters long (tip of nose to tail-tip) upon initial capture. She was subsequently captured three more times during her lifetime and ranged in weight from 19.6 to 25.1 kg (see Way et al. 2001, 2002a; Way and Proietto 2005; and Way 2007*). Following capture, she was fitted with a radio-collar or it was replaced (MOD 335 and MOD 400 collars; Telonics Inc., Mesa, Arizona, USA) for monitoring purposes. Radio-telemetry protocols are fully described in Way et al. (2002a) and Way et al. (2004). Portable receivers (Custom Electronics, Urbana, Illinois, USA) and hand-held 3-element Yagi antennas were used to radio-track both on foot and from a vehicle. The abundance of roads restricted our activities to cars, as Coyotes did not react to them as much as to people (e.g., by running away; J. Way, unpublished data). Occasionally we approached the Coyote as close as possible on foot without disturbing her. Using a vehicle, we homed in on the animal's signal until its

location was pinpointed by using the loudest-signal method (Way et al. 2004). We used binoculars, spotting scopes, and video-cameras during daytime observations, and city street lights, night vision scopes, binoculars, and headlights during nighttime observations (Way et al. 2002a, 2004).

To estimate home ranges (1998–2006/2007), we used Home Range Tools for ArcGIS extension using ArcGIS Version 9.2 (Rodgers et al. 2007). Home ranges/territories were calculated using the 100% and 95% Minimum Convex Polygon (MCP) methods. We conducted a Chi-square (χ^2) test of homogeneity to examine the proportion of successful vs. unsuccessful radio-locations compared between 1998–2004 and 2005–2007.

Observations

Territorial phase (1998–2004)

The studied individual was the breeding female of the “Cummaquid pack” from 1998 to 2004. During that time, she used a consistent territory of approximately 30 km² (95% MCP; Tables 1 and 2, Figures 1 and 2), led a pack of three to four adults (winter observations,

after pup dispersal), and gave birth to an average of five pups in early April (Way et al. 2001) of each year. We obtained 1097 telemetry-locations on the Coyote during this time (Table 1), excluding April 2002 – March 2004 when she wore a non-functioning radio-collar. However, based on Coyote observations in the area, it appears that she whelped a litter during summers 2002 and 2003 as she localized in April 2002 prior to her second collar's failure. In March 2004 she was observed traveling in a pack of four full-sized individuals, with one or two of those animals likely being her pups from 2003 (Gese et al. 1996; Way et al. 2002a).

Nomadic phase #1 (January 2005 – March 2006)

Her behavior changed dramatically in January 2005 when, during a two-week period when 90 cm of snow fell, she was located on six occasions sleeping under sheds and/or decks (Figure 3) in highly residential neighborhoods at the southeastern edge of her range (Figures 1 and 2). During this period JGW observed a superficial wound on her left flank (which appeared to be Coyote-inflicted) though she otherwise appeared to be healthy. After six years of tracking her, JGW had the impression that something happened (i.e., a confrontation with other Coyotes) that may have caused this change in her behavior. Also, a few days before she was documented off-territory, JGW observed two other Coyotes vigorously scent-marking and ground-scratching sandpits in the southwestern portion of her former range.

The Coyote was nomadic for approximately 1.5 months until 11 March 2005, when she localized in a small area (95% MCP range = 5.85 km² and 100% MCP range = 7.89 km²; Figures 1 and 2) in the northeastern portion of the study area until 1 March 2006. While she was in that small area, we obtained 283 locations on her, visually observing her on 13 times: (1) alone during six occasions, (2) with another Coyote during four occasions (likely the same individual on all four occasions based on physical appearance) over a 9-month time-span (April 2005 – January 2006), and (3) three times in a one-week stretch during late-February 2006 with her former mate (wearing a non-functioning collar from 2001 to 2006; see Way 2007*) and, on the last of those observations, also with a third, very large gray individual. Shortly after this observation (1 March 2006), she became nomadic and left the northeastern portion of her range for the southeastern region (i.e., the area where she was first located when leaving her territory in January 2005). During her tenure in the northeastern portion of her old range (i.e., 2005-2006; Figure 1) she did not give birth (or localize) despite being located with other Coyotes during 7/13 (~54 %) of our direct observations of her.

Nomadic phase #2 (March 2006 – February 2007)

It was more difficult to locate the Coyote during 2005-2006 (after she abandoned her territory) than

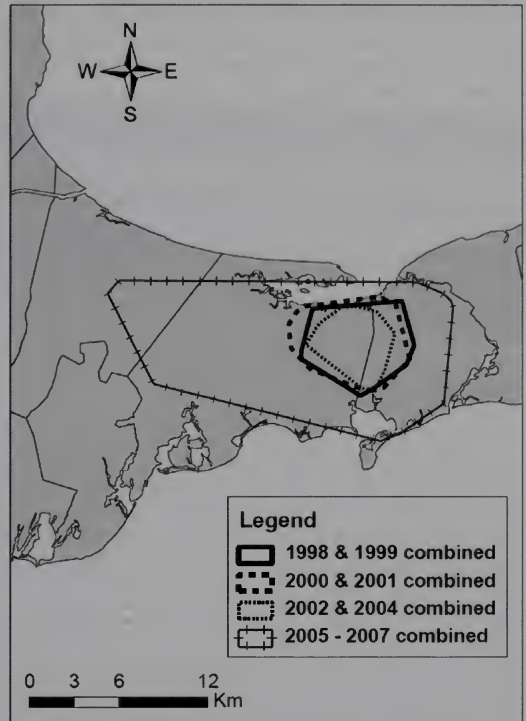


FIGURE 2. Eastern Coyote #9804's 95% minimum convex polygon home ranges on Cape Cod, Massachusetts grouped by 2-year combinations. No locations were taken in 2003 because her collar was non-functioning.

when she held a territory (i.e., 1998-2004; $\chi^2 = 47.6$, $df = 1$, $P < 0.0001$; Table 1). Because we were unsuccessful in obtaining a location for her during a large number of attempts in 2006 (Table 1), her home range for this period should be considered a minimum estimate, as she undoubtedly used areas outside of the 2006 polygon (Table 1, Figure 2). While it intuitively might be expected that we would have less success (~ five times more unsuccessful finds [11% vs. 2%] in 2006/2007 vs. 1998-2004) locating her in 2006/07 due to her larger range compared to previous years (i.e., approximately five to ten times larger during 2006-2007 compared to 1998-2004), we always managed to locate her the next day after not finding her in 1998 (unsuccessful locations were likely because of researcher inexperience), and in 2002 she had a weak battery which ultimately died, making her difficult to find. However, at the end of 2006 and into 2007 she was often not located for two to three months at a time and we believe she was off our study area during those unsuccessful finds (Table 1).

The Coyote's range during 2006 had minimal overlap with her former range (i.e., 1998 – 2004), suggesting that she avoided her original territory (Table

2). Between March 2006 and February 2007 we observed the Coyote 28 times and she was alone every time. An additional two sightings involved Coyotes sighted in close proximity (< 200 m) to her though not with her. The day after both of these observations, the Coyote moved a considerable distance away from the immediate area including a 5.7 km straight-line movement within a 24-hour time frame from the southeastern to the northeastern portion of her range (Figure 1) in late-March 2006. We do not think that humans influenced these movements as we often observed her during her territorial phase (i.e., 1998 – 2004; > 50 observations) and she never displayed dramatic movements following a sighting even when she was disturbed (i.e., by headlights).

General nomadic phase observations

Analyses of movements post-January 2005 (Figure 1) indicate that the Coyote used clustered areas, generally spending more time in areas where other radio-collared Coyotes were not located (J. Way, unpublished data). Interestingly, we observed Red Foxes (*Vulpes vulpes*) in close proximity (about 100 to 200 m) to the Coyote during 15 to 20 observations of her during 2006 but never saw foxes near her from 1998 to 2004 when she was part of the Cummaquid pack. Also, many of the observations from 2005 – 2006 were in highly residential areas (including Hyannis, 556 people/km², the most urban part of Cape Cod), where radio-collared territorial resident Coyotes spent little time (J. Way, unpublished data).

Discussion

This study documents the movements of a post-territorial canid. This animal was a survivor, living a long full life in an urbanized area, but exhibiting behavior typical of a wild Coyote by avoiding people, living in a pack, and having a large territory (Way, 2007*). The extensive duration of our study on this particular Coyote (i.e., 1998–2007) enabled us to compare movement patterns between years when she was reproductive to years when she was not. Our results indicate that the Coyote maintained a relatively consistent territory during years when she whelped pups (1998 – 2004; Table 2, Figure 2) and then, during the final two years of her life (early-2005 to early-2007), her movement patterns changed dramatically. After becoming post-territorial in 2006/2007, she used an area of ~ 200 km², which was considerably larger than her annual territories from 1998–2004 (Table 2; Figure 2) but small when compared to long-distance movements observed in transient/nomad Wolves (Gese and Mech 1991; Mech and Boitani 2003a) and Coyotes (Way 2007). Such observations suggest that the classification of Coyotes as either residents (breeders/alphas, associates/betas/helpers, and juveniles/pups) or transients/nomads (Andelt 1985; Person and Hirth 1991; Patterson and Messier 2001; Way et al. 2002a) may be too simplistic. For example, Crabtree and Sheldon

(1999) described a subclass of solitary Coyotes, called “former alphas”, who maintain a degree of site fidelity within a general area. It seems then that there may be (at least) two classes of nomadic/transient Coyotes: (1) “dispersers”, who leave their natal range and settle in new, often distant areas (as is most frequently reported in the literature – e.g., Gese and Mech 1991; Way 2007); and (2) “floaters”, who are animals that remain in a relatively localized area (though larger than an average pack’s territory) moving in and out of existing pack mosaics, presumably looking for a territorial vacancy. Scenario number two is similar to many species of birds, such as Black-capped Chickadees (*Parus atricapillus*), which have non-territorial but locally knowledgeable floaters living amongst territorial families (Smith 1988). Under this classification scheme, the Coyote reported in this paper would be categorized as a “floater”. Floaters (and other transients) presumably claim vacated territories following the death of resident territory holders.

In addition to the dramatic changes in movement patterns post-2004, the Coyote’s behavior seemed to change during that period as well. First, we observed her six times sitting/hiding under decks and/or sheds (Figure 3) but never documented her using human structures for rest/denning the previous six years (Way et al. 2001). F. Harrington (personal communication) noted a young male Wolf (#2489) in Minnesota that similarly localized following the abandonment of his natal territory after his father died. The Wolf appeared to be in a state of shock, yet was alive and eventually emigrated 160 km away. Perhaps when Wolves/Coyotes are forced to leave their territories through social expulsion, the animals sink into an apparent state of depression and hide from other canids (F. Harrington, personal communication). Second, while radio-tracking the Coyote as a territorial pack member (1998–2004), we regularly heard (and video-recorded) her group howling (i.e., at least twice a week). However, we heard her vocalize only three times during her nomadic phase(s) (i.e., early-2005 to early-2007): (1) on 24 April 2005 at 2124 h when she and one or two other Coyotes engaged in a high-pitched and wailing group howl; (2) on 12 May 2005 at 2128 h, when she and a second Coyote called each other via lone howls (or contact calls); and (3) on 9 August 2005 at 2128 h, when a short bark and brief howl were heard near her location; this sounded like a warning call (Lehner 1978). These vocalizations occurred when she was traveling with another Coyote and living in a small home range (and possible territory) for 11 months at the northeastern edge of her former territory. This behavioral shift (i.e., lack of howling) by this Coyote may have been an attempt to avoid resident Coyote packs, similar to the behavior exhibited by Wolves to avoid resident Wolf packs (Mech and Boitani 2003a, b). As a long-lived individual, her knowledge of the area likely helped her to navigate around resident core



FIGURE 3. Coyote #9804 sitting under a shed (January 2005) in a residential area at the southeastern portion of her former range, in West Yarmouth, Cape Cod, Massachusetts.

use areas, although the high number of unsuccessful finds for her in 2006 also suggests that she explored surrounding areas potentially inhabited by other (uncolored) packs. Third, Red Foxes were seen in close proximity to the Coyote (< 200 m) much more frequently during her nomadic phase(s) than during her territorial phase (i.e., 1998 – 2004). Our data indicated that she lived at the periphery of resident Coyote packs' ranges, and in more clustered areas, likely a tactic to avoid encountering resident Coyotes (Figure 1). Larger canids are dominant over smaller ones, (e.g., Wolves over Coyotes and Coyotes over Foxes) (Major and Sherburne 1987; Harrison et al. 1989; Johnson et al. 1996) and therefore the observations of foxes in close proximity to the Coyote suggests that she may have been perceived as less of a threat by foxes during her nomadic phase, she may have been less aggressive to the foxes, and/or that both the Coyote and foxes were spending the majority of their time in areas of low use by resident Coyote packs.

We suggest that one possible mechanism for this dramatic range shift is that the Coyote, due to her advanced age (i.e., she was ~ 10 years-old in 2005), became post-reproductive and may have been unable to defend (or relinquished) her original (i.e., 1998-2004)

territory. Sacks (2005) found that female Coyotes in California reproduced at eight and nine years old in that short-lived population (mean age of females was about three years old), while Dumond and Villard (2000) noted reproduction in 83% ($n = 6$) of female Coyotes > 8 years old in New Brunswick. Our study subject successfully reproduced until 10 years old even though she tested positive for heartworm and Lyme disease during her previous captures. Possibly the combined effects of these parasites and her advanced age caused her loss of vigor and subsequent abandonment (or loss) of her territory.

This study illustrates the importance of (1) long-term studies of individuals; (2) documenting the fate of old, possibly post-reproductive canids; and (3) providing an account of the behavior of a formerly territorial canid that lost its territory and became a floater. Researchers should not ignore the importance of monitoring individuals throughout their lives to gain a more accurate behavioral profile of the species.

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ADDENDA:

While this paper was in press, the eastern Coyotes have been demonstrated to be hybrids from crosses between the Western Coyote, *Canis latrans*, and the Eastern Wolf, *Canis lycaon*, and should now be referred to as "Coywolf" *Canis latrans* × *lycaon*.

In press: Genetic characterization of eastern "coyotes" in eastern Massachusetts" by Jonathan G. Way, Linda Rutledge, Tyler Wheeldon, and Bradley N. White. *Northeastern Naturalist* 17 (2010).

Grizzly Bears, *Ursus arctos*, in Wapusk National Park, Northeastern Manitoba

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We report on nine sightings of Grizzly Bears (*Ursus arctos*) in northeastern Manitoba in what is now Wapusk National Park. Although biological research in the region has been conducted regularly since 1965, all sightings have been made since 1996. The Grizzly Bears were seen either along rivers known to harbor fish or in an area known for berries.

Key Words: Grizzly Bear, *Ursus arctos*, Wapusk National Park, Manitoba, Canada.

Grizzly Bears (*Ursus arctos*) are reported to have been absent from Manitoba historically at least through 1989 (Banfield 1959, 1974; Harington et al. 1962; Banci 1991, McLellan And Bianci 1999). Some recent accounts and range maps have included Manitoba in the Grizzly Bear's regular range (e.g., Schwartz et al. 2003), while others indicate that the regular range ends north of the Manitoba border but list rare, extra-limital observations for at least two sites along the Hudson Bay coast of Manitoba (e.g., Ross 2002*). Increased encounters with Grizzly Bears in northern Manitoba could be the result of increased observational effort or the expansion of the species' range. The latter could indicate a geographic shift related to habitat changes or food availability in the core areas and/or the newly occupied territory or to growth or other changes in the demographic structure of the core population followed by dispersal into unoccupied habitat.

In this paper, we extend the work of Clark (2000) and update confirmed observations of Grizzly Bears in the coastal sections of the Hudson Bay Lowlands east and south of Churchill, Manitoba (in what is now Wapusk National Park). We confine our primary efforts to this region since research there has been ongoing since 1965 and at a consistent level since 1993. As such, any recent increase in the frequency of Grizzly Bear encounters is more likely to be related to increased presence of the animals than increased efforts to find them. Because this new National Park is in the process of developing its status and mission plans, we also speculate on how regular occupation of the park by Grizzly Bears could influence some of the other species that have historically occupied the area.

While there have been occasional reports of Grizzly Bears or their sign since the onset of research in this area (e.g. Figure 1), we have limited the observations for this paper to confirmed sightings, as suggested by Clark (2000). Confirmed sightings require that either



FIGURE 1. Claw marks assumed to be made by a Grizzly Bear were observed in the tundra along the north coast of Wapusk National Park on 29 May 2006. The penknife is 12 cm.

the large hump of muscle over the scapulae or the concave face typical of Grizzly Bears be clearly seen by individuals familiar with the species. Nine encounters are summarized in Table 1 and to our knowledge they are the only confirmed sightings for this region since research began in 1965. Seven of the nine have been made since 2003 and the locations of all nine are depicted in Figure 2. The photograph of the most recent observation appears on the cover of this issue of *The Canadian Field-Naturalist* and the animal clearly shows the diagnostic scapular hump and concave face of a Grizzly Bear.

Comparisons of photographs from the three 2008 observations (Table 1) suggest that the animal seen near Rupert Creek may not have been the same animal as the ones seen near Thompson Point since it ap-

TABLE 1. Confirmed sightings of Grizzly Bears in Wapusk National Park.

Encounter	Date	Location	Details	Authority ¹
1	15 June 1996	58.23333N 93.06667W; Approximately 7 km inland near Thompson Point	Seen from fixed-wing survey plane and photographs were taken. Hump and concave face were clearly seen and are obvious in photograph.	Dale Humburg ^a
2	5 June 1998	58.33333N 93.03333W; Coastal beach ridge near Thompson Point	Seen from helicopter. Hump and concave face were seen clearly.	Doug Clark ^b
3	Summer 2003	Near the coast at the Owl River	Seen from helicopter and photographs were taken. Hump and concave face clearly visible.	Robert Rockwell ^c
4	Summer 2004	Near the coast at the Broad River	Seen from helicopter and photographs were taken. Hump and concave face are clearly visible.	Bob Reside ^d
5	6 July 2004	58.13515N 92.86322; Broad River cabin	Seen 3 metres from cabin door. Concave face clearly seen.	Melissa Gibbons ^e
6	Summer 2005	Near the coast at Rupert Creek	Seen from helicopter. Hump and concave face were clearly seen.	Bob Reside ^d
7	22 July 2008	57.56758N 92.55860W; Near coast north of Rupert Creek	Seen from fixed-wing aircraft and photographs were taken. Hump and concave face were clearly seen.	Shaun Bobier ^f
8	1 August 2008	58.28953N 93.00608; Near coast south of Thompson Point.	Seen from helicopter and photographs were taken. Hump and concave face were clearly seen.	Daryll Hedman ^g
9	9 August 2008	58.36613N 93.08047W; 2 km inland and 9 km north- west of Thompson Point	Seen from helicopter and photographs were taken. Hump and concave face clearly seen.	Robert Rockwell ^c and Linda Gormezano ^c

¹ Individuals who saw the animal or examined the pictures and confirmed it was a Grizzly Bear. ^aDucks Unlimited, Memphis, Tennessee; ^bUniversity of Alberta, Edmonton, Alberta; ^cAmerican Museum of Natural History, New York, New York; ^dRiding Mountain National Park, Wasagaming, Manitoba; ^eWapusk National Park, Churchill, Manitoba; ^fManitoba Conservation, Churchill, Manitoba; ^gManitoba Conservation, Thompson Manitoba

pears to be substantially larger. In contrast, the individuals in the latter two sightings (that were made less than a week and less than 10 km apart) could not be distinguished. We suggest at least two different Grizzly Bears may have been present in Wapusk National Park in 2008.

Given their enormous home ranges (11 400 km², Gau et al. 2004) and flexible habitat requirements (Schwartz et al. 2003), it is not surprising that Grizzly Bears have extended into areas such as Wapusk National Park that are only a few hundred kilometres south of their regular range. Three confirmed observations of Grizzly Bears since 1990 north of Churchill, Manitoba, further support that interpretation. The dates and locations of those encounters are: 27 July 1990 at 59.56667°N, 94.86667°W (in Clark 2000); 13 September 2005 at 59.89944°N, 97.03889°W and 28 June 2007 at 59.39383°N, 94.77224°W (both D. Hedman, unpublished data).

Wapusk National Park contains ample supplies of animal and plant resources known to be used by Grizzly Bears (Barry 1967; Gau et al. 2002; Ross 2002*; Schwartz et al. 2003). Of particular note are the more than 50 000 pairs of nesting Lesser Snow Geese (*Chen caerulescens caerulescens*), a potential food source already being exploited by Polar Bears (Rockwell and

Gormezano 2009). Nesting Snow Geese are found within the Grizzly Bear's range in Nunavut but are absent between there and Wapusk National Park. The park also contains substantial populations of Canada Geese (*Branta canadensis*) and both Caribou (*Rangifer tarandus*) and Moose (*Alces alces*). The park is rich in various arctic berries, especially cloudbberries (*Rubus chamaemorus*) and blueberries (*Vaccinium uliginosum*) (R. L. Jefferies, personal communication). The streams associated with five of the nine sightings (Figure 2) contain fish (R. F. Rockwell, unpublished data), and the Thompson Point area, where the other four sightings occurred, was traditionally used by local Cree First Nation communities for berry harvests (Flora Beardy, personal communication). The inland portions of the park include extensive peat plateaus and outcroppings used for winter denning by Polar Bears (*Ursus maritimus*) (e.g., Clark et al. 1997). These could certainly provide Grizzly Bears with winter haven.

The presence of Grizzly Bears raises interesting potential issues for other species in Wapusk National Park. Grizzly Bears are known to be exceptionally efficient predators of both Caribou and Moose (Ross 2002*) and would place new predation pressure on those species. Such predation would provide competition for both Wolves (*Canis lupus*) and Polar Bears,

although Grizzly Bears are known to provide scavenging opportunities for other such species (Ross 2002*). Female Polar Bears and their new cubs become active in the early spring in the interior portions of the parks and if Grizzly Bears were also to den there, encounters between the two species would be likely but the outcomes uncertain. There are reports and speculation that Grizzly Bears kill and consume female Polar Bears and their cubs but also that Polar Bears may prey on denning Grizzly Bears (Taylor 1995; Doupé et al. 2007). Although such events might be rare, informed management plans for interior portions of Wapusk National Park should consider them. Finally, there are several reports of natural hybridization between Grizzly and Polar bears, the most recent being the well-publicized hybrid harvested in 2006 near Sachs Harbor on Banks Island (Taylor 1995; Schliebe et al. 2006). Such hybridization could potentially complicate issues related to genetic integrity and identification of the two species and their hybrids.

The observations presented here are consistent with the range map presented in Schwartz et al. (2003) that includes northeastern Manitoba in the range of Grizzly Bears. It is not yet clear whether the individuals encountered are transients, perhaps making use of higher levels of seasonally available food, or are more permanent residents. Continued and especially consistent monitoring will help resolve the Grizzly Bear's status and establish whether their abundance is increasing in northeastern Manitoba.

Acknowledgements

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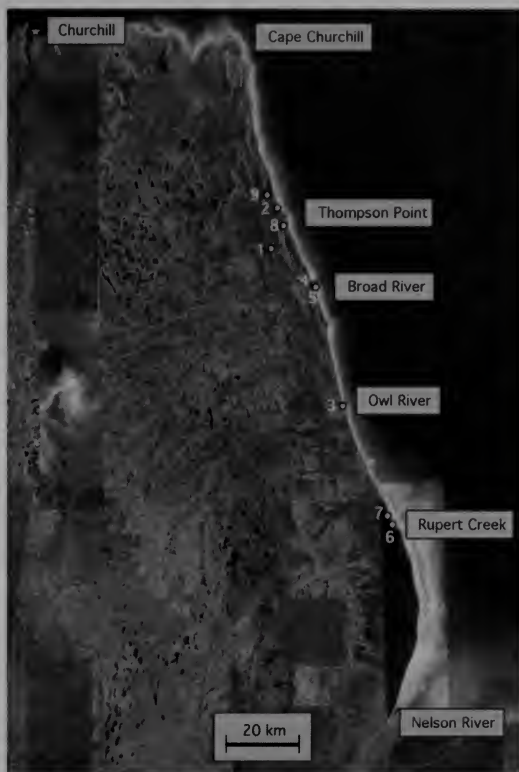


FIGURE 2. Locations of the nine confirmed Grizzly Bear sightings in Wapusk National Park. See Table 1 for numbers.

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Critical Habitat and the Conservation Ecology of the Freshwater Parasitic Lamprey, *Lampetra macrostoma*

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Lampetra macrostoma, the Cowichan Lamprey, is a freshwater parasitic lamprey that probably evolved from *L. tridentata* within the last 10 000 years. It is unique to the Cowichan Lake watershed on Vancouver Island, British Columbia, Canada. Larval rearing in Mesachie and Cowichan lakes occurs in shallow, silt-covered gravel areas at the mouths of rivers and streams flowing into the lakes. Spawning occurs over a protracted period from early May until about late July. Shallow areas with small gravel along the shore of the lakes, near the mouths of rivers are essential for successful spawning. Adults prey on a variety of salmonid species within the lake. There has been considerable development around Mesachie Lake and reported increased fishing pressure on prey in Mesachie and Cowichan lakes. It is not known if the size of the population of *L. macrostoma* has changed since an initial study in the early 1980s, but a study in 2008 captured very few spawning lamprey in Mesachie Lake, possibly indicating that the population is declining.

Key Words: Cowichan Lamprey, *Lampetra macrostoma*, critical habitat, conservation, Mesachie Lake, Cowichan watershed, British Columbia.

The lamprey *Lampetra macrostoma* was first described in 1982 (Beamish 1982) as a freshwater parasitic derivative of *Lampetra tridentata*. It differs from *L. tridentata* because of the size of its oral disc, which in immature *L. macrostoma* ranges from 8.8 to 11.4% of the total length (TL) compared to 4.6 to 9.1% TL for *L. tridentata* (Beamish 1982). *L. macrostoma* is also distinguished from *L. tridentata* by a longer prebranchial length, a larger eye, weakly pigmented velar tentacles and an ability to remain and feed in fresh water prior to spawning (Beamish 1982). Youson et al. (1988) showed that there are differences in the pancreatic tissue distribution that would further support the separation of *L. macrostoma* and *L. tridentata*. Beamish (1982) held recently metamorphosed *L. macrostoma* and *L. tridentata* in fresh water beginning in October. By the end of November, 50% of *L. tridentata* had died and the remaining *L. tridentata* animals had died by March of the following year. All of the *L. macrostoma* survived.

Lampetra macrostoma spawn later in the year and at a smaller size (Beamish 1982) than most *L. tridentata*. Beamish and Neville (1992) showed that spawning success of lamprey declined when the length differences between male and female spawning lamprey differed by more than 20%. At size differences greater than approximately 25%, spawning was not successful. Thus it is unlikely that *L. macrostoma* could interbreed with larger, anadromous *L. tridentata*. It is likely that homogamy [the need for spawning male and female lampreys to be of equal size (Hardisty and Potter (1971a))] is the mechanism that contributed to the isolation of *L. macrostoma* from *L. tridentata*. Addi-

tionally, different spawning times and locations could contribute to the speciation.

Recently, McPhail (2007) reported that the taxonomic status of *L. macrostoma* was unclear. McPhail and Lindsey (1970) considered that a species designation was appropriate if the fish in the population were morphologically distinguishable and not successfully interbreeding with closely related species. *L. macrostoma* and *L. tridentata* are morphologically distinguishable. It has not been determined if *L. tridentata* are present in Mesachie and Cowichan lakes but they are in the Cowichan watershed. However, if the two species do or did occur sympatrically, it is unlikely that they are capable of interbreeding because of the smaller size and late spawning time of *L. macrostoma* compared to *L. tridentata* (Beamish and Neville 1992). It is also relevant that the morphological differences between *L. macrostoma* and *L. tridentata* are consistent with differences used to separate other species of lampreys. *Lampetra ayresii*, for example, was originally distinguished as a species from *L. fluviatilis* because of a larger eye, a longer prebranchial and a shorter branchial region (Vladykov and Follett 1958). *L. richardsoni* was mainly distinguished from *L. planeri* by a longer branchial region (Vladykov and Follett 1965). The differences that separate *L. macrostoma* and *L. tridentata* are also consistent with the differences that separate the derivatives of *L. tridentata* (Table 1). Thus, the designation of *L. macrostoma* as a distinct species is important as it is clearly distinguishable from *L. tridentata* and needs to be managed separately.

It is probable that the differences between *L. macrostoma* and *L. tridentata* developed in the last 10 000

TABLE 1. Characters that distinguish derivatives of *Lampetra tridentata*.

Species	Distinguishing characters	Reference
<i>L. similis</i>	Larger disc Smaller eye Fewer velar tentacles	Vladykov and Kott 1979
<i>L. macrostoma</i>	Larger disc Longer pre branchial length Larger eye In freshwater	Beamish 1982
<i>L. minima</i>	Small size Remains in freshwater Fewer velar tentacles Large eye Longer pre branchial length	Bond and Kan 1973 Lorion et al. 2000
<i>L. lethophaga</i>	Non parasitic Fewer velar tentacles	Hubbs and Potter 1971 Vladykov and Kott 1976b
<i>L. folletti</i>	Non parasitic Fewer velar tentacles Large disc	Vladykov and Kott 1976a
<i>L. hubbsi</i>	Non parasitic Reduced dentition Fewer myomeres Reduced number of velar tentacles	Vladykov and Kott 1976b Vladykov and Kott 1984

years after the last glaciation of the area and after the drainage of Cowichan Lake changed (Beamish 1982). There are other examples of recent and rapid speciation among lamprey. The nonparasitic species, *L. planeri*, for example was considered by Hubbs and Potter (1971) to have separated from *L. fluviatilis* within the past 10 000 years. The mechanisms that result in rapid speciation within lampreys are not known, but are believed to be a factor in the success of lampreys over the past millions of years (Beamish 1985). *L. macrostoma* and its ecosystem provide an excellent opportunity to study the processes that form species of lamprey and species in general. Thus, although it may be worrisome to understand how *L. macrostoma* diverged from *L. tridentata*, we consider that there is not only ample precedent to maintain the designation of *L. macrostoma* as a distinct species but there is also an obligation to protect the species.*

In this report we present information about the critical habitat of *L. macrostoma* collected at the time the species was first described, but not previously published. We use this information and the results of a recent study in Mesachie Lake to comment on the im-

portance of ensuring that *L. macrostoma* and its ecology are protected. We also identify areas of research that will help understand how *L. macrostoma* evolved and suggest how lampreys in general adapt to changing ecosystems by changing their life history.

Study Area

Mesachie Lake (Figure 1) is located in south central Vancouver Island, Canada (48°48'50"N, 124°06'54"W). It is a small lake with an elevation of 168 m, a total surface area of 59.3 ha, a maximum depth of 32 m and a mean depth of 19.3 m (Province of British Columbia, GeoBC*). Two streams flow into Mesachie Lake. Halfway Creek flows into the east end of Mesachie Lake. Mill Creek is a small intermittent stream flowing into the southwest corner of the lake in the winter that is virtually dry in the summer. Mesachie Creek connects Mesachie Lake to Bear Lake, which then flows into McKenzie Bay in Cowichan Lake (Figure 1). Mesachie Creek has intermittent flows and can be completely dry in areas in the summer. In some years the creek was dry in areas by early May. Cowichan Lake connects to the Strait of Georgia through the Cowichan

* *Lampetra macrostoma* was given the common name, Lake Lamprey (Beamish 1982) because the species spawned and spent its larval and adult life in a lake. The anadromous parasitic lamprey *L. ayresii* that spawns and rears as an ammocoete in large rivers (Beamish 1980) has the common name, River Lamprey and it seemed fitting that *L. macrostoma* could be identified as the Lake Lamprey. However, Nelson et al. (2004) changed the name to the Vancouver Lamprey. The common name Vancouver Lamprey has little meaning as it implies that the species is associated with the city of Vancouver. The name Cowichan Lake Lamprey or Mesachie Lake Lamprey does make sense as the species occurs in both these lakes (Figure 1). However, if the common name must change, we prefer the name Cowichan Lamprey in reference to its occurrence in the Cowichan Lake drainage.

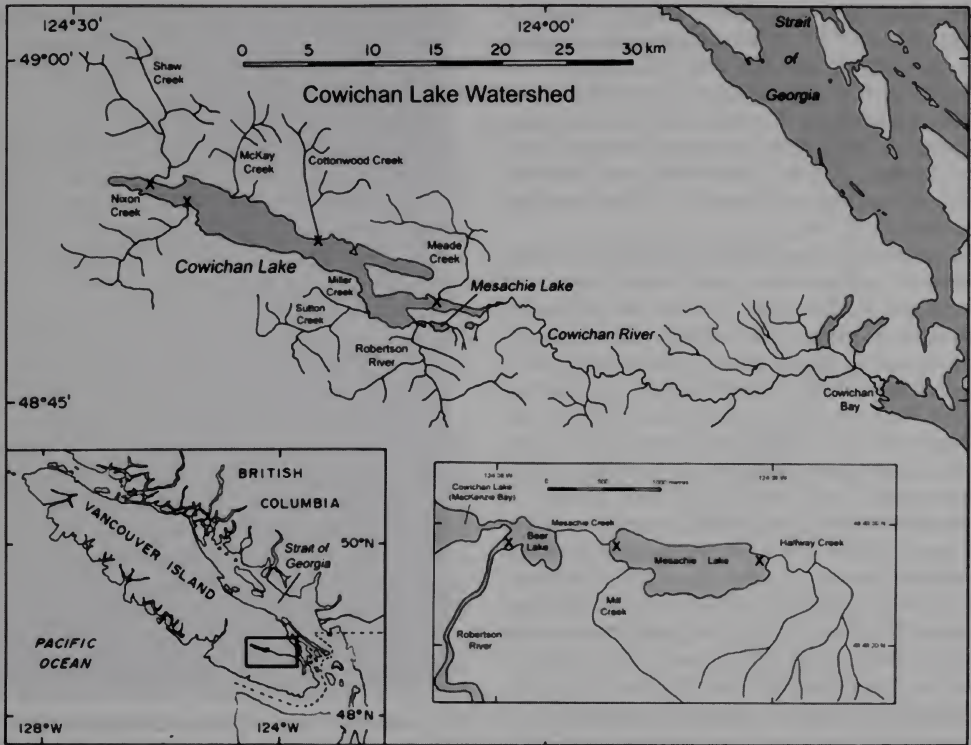


FIGURE 1. Map of Cowichan Lake watershed including a detailed inset map of Mesachie Lake and location of electroshocking sites where ammocoetes were present (X).

River. Cowichan Lake and Mesachie Lake have a similar elevation (164 m), but Cowichan Lake is much larger with a surface area of 6204.3 ha and a maximum depth of 152 m. The Cowichan River flows out of the southeast end of Cowichan Lake (Figure 1) and into the Strait of Georgia, a linear distance of 35 km from the lake outlet to the river mouth.

Methods

Initial Study

The first studies of *L. macrostoma* occurred from 1979 to 1985. Initially, it was not known that it was a distinct species and the studies identified the rearing areas of ammocoetes and the adult spawning areas of what was believed to be a nonanadromous form of *L. tridentata*. The habitat used by ammocoetes was determined in Mesachie Lake and Cowichan Lake using electroshockers. Virtually all of the shallow shoreline around Mesachie Lake was surveyed. Selected areas in Cowichan Lake were surveyed and only the sites that contained ammocoetes were identified. In May 1982, bottom depths greater than 2 m were electroshocked from a boat. Spawning lampreys in Mesachie Lake were collected using traps (Figure 2a). Traps were set from the late spring to early summer on the gravel bar at the junction of Halfway Creek and Mesachie

Lake (Figure 1). In 1980 and 1981, unbaited wire minnow traps were placed along a mesh barrier. A trap net was positioned at the deep end of the barrier (Figure 2b). A barrier and a similar trapping arrangement were placed near the mouth of the Robertson River in 1981. The Robertson River flows into Bear Lake which is downstream from Mesachie Lake and drains into Cowichan Lake (Figure 1). In the summer and fall there may be no surface flow from the river into Bear Lake. Surveys of ammocoetes and metamorphosing juvenile lamprey were carried out in the Cowichan River between 1985 and 1988, after the lamprey in Mesachie and Cowichan lakes were recognized as a distinct species. All ammocoetes were identified using the criteria in Richards et al. (1982). It is important to note that ammocoetes of *L. macrostoma* could not be distinguished from ammocoetes of *L. tridentata* using the approach in Richards et al. (1982). Metamorphosed and adult lamprey were readily identified using disc and eye size.

Coho Salmon Study

A separate study of Coho Salmon (*Oncorhynchus kisutch*) movement in and out of Mesachie Lake occurred from 1988 to 1996. This area was chosen because the Cowichan Lake drainage area traditionally was a major spawning area for Coho Salmon. Ana-

dromous Coho Salmon spawn in Halfway Creek. A fence was installed 365 m downstream of the junction of Mesachie Creek and Mesachie Lake. Traps were installed at the fence that captured all downstream and upstream migrating fish. As a part of this seasonal monitoring program, which took place mainly between October and January, lamprey ammocoetes and metamorphosed lampreys that were found in the traps were also enumerated.

Metamorphosed lampreys were not identified using morphometric measurements, and no specimens were saved. In many cases, there were no written reports separating ammocoetes from metamorphosed individuals or separating mature adults from recently metamorphosed individuals. Counts and date of capture of lampreys, however, were recorded. It is probable that the ammocoetes were all *L. macrostoma* but it is not possible to distinguish them from *L. tridentata*, except that spawning *L. tridentata* have not been reported in the same areas. When Coho Salmon smolts were caught it was noted whether or not they had lamprey scars and fresh wounds. A series of reports by Aquatic Resources Ltd. (available from the library at the Pacific Biological Station, Nanaimo, British Columbia) summarized the annual observations of this study. Our summary is based on the original field records which were given to us, and the reports by Aquatic Resources Ltd.

Recent Study

In May and June of 2008, trapping experiments were repeated in Mesachie Lake as they had been conducted in 1980 and 1981 but without the trapnet at the deep end of the barrier fence and at both the inlet and outlet streams to Mesachie Lake. Trap lines were set up with unbaited minnow traps along a black Vexar fence held in place with rebar, at the junctions. Initially, traps were checked every day. After the first two weeks, traps were checked every second day. The contents of individual traps were identified and animals released.

Results

Ammocoetes were found in selected shallow areas along the shore of Mesachie Lake and Cowichan Lake (Figure 1). Ammocoetes were found in bottom habitat where a thin layer of silt covered firmer sediments that included fine sand and small gravel or fine woody debris. Ammocoetes were not found in shallow areas where silt was deeper than about 10 cm. In Mesachie Lake, most ammocoetes were found along the shoreline close to the inlet stream. Some ammocoetes were of in the inlet stream within approximately 100 m of the lake but none were found beyond this area. Very few ammocoetes were found in the outlet stream. Small numbers (<10) of ammocoetes were observed in the lake in the immediate vicinity of the outlet stream, but the catches were substantially smaller than around the mouth of the inlet stream.

It was difficult to determine if ammocoetes occurred in deeper areas. However, on 7 May, 1982, six

ammocoetes (120.0-150.0 mm) and one mature adult were captured after 3½ hr of electroshocking from a boat in areas approximately 2 m deep immediately in front of the main inlet stream.

A shallow, silt covered, small gravel bar along the east shore of Bear Lake at the junction of the Robertson River contained ammocoete densities in 1979 and 1980 that were estimated to be about one third of the density in the gravel areas around the mouth of the inlet creek in Mesachie Lake. On 20 September, 1985 a sample of five recently metamorphosed *L. macrostoma* ranged from 108 mm to 127 mm and averaged 115 mm. A sample of 64 ammocoetes ranged from 68 mm to 138 mm and averaged 102 mm.

Ammocoetes were collected in the shallow silt covered, small gravel areas of Cowichan Lake from 1980 to 1982, near the mouths of Nixon Creek, Shaw Creek, Cottonwood Creek and near the outlet of Meade Creek (Figure 1). Ammocoetes were not found in any of the rivers flowing into the lake beyond about 100 m from the mouth of the river. In May 1980, a sample of 227 ammocoetes ranging in length from about 100 to 170 mm was collected from the shallow gravel and fine sediment area adjacent to Shaw Creek. They were transported to the laboratory at the Pacific Biological Station, Nanaimo, British Columbia where they were fed brewer's yeast until October 1981 when 59 had completed metamorphosis. All 59 were determined to be *L. macrostoma* (Beamish 1982). Thus, it was confirmed that ammocoetes of *L. macrostoma* were in the shallow gravel areas near the mouth of Shaw Creek in particular and probably in similar areas near rivers that flow into Cowichan Lake.

Other Species of Ammocoetes

No *L. richardsoni* ammocoetes were found in any of the collections from the lakes or rivers flowing into Cowichan Lake or in Mesachie Lake. However, the surveys of rivers flowing into Mesachie Lake and Cowichan Lake were restricted to distances less than about 100 m from the river mouth. Ammocoetes of *L. ayresii* are readily identified (Richards et al. 1982) and none were found.

Spawning Habitat and Spawning Times

Lampetra macrostoma in spawning condition were captured in the gravel areas adjacent to the mouths of the inlet creek in Mesachie Lake and the Robertson River from mid-May until late August (Figure 1). On 2 May 1982, one mature *L. macrostoma* was captured in Halfway Creek, a short distance from the lake. This was the only adult *L. macrostoma* captured in any of the river and creek electroshocking studies. No lampreys were observed spawning or guarding nests despite frequent visits by people attending the traps.

In 1980, 124 mature and maturing *L. macrostoma* were captured in the traps at the barrier fence in Mesachie Lake between 3 May and 18 August (Figure 3). Traps were set between 3 May and 18 September.

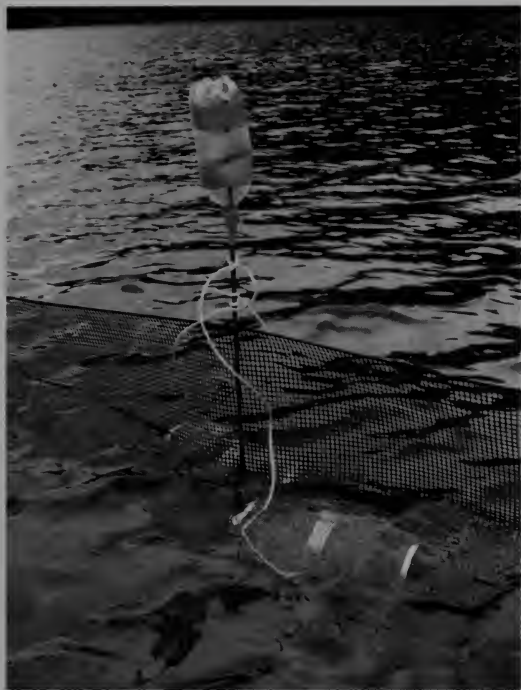


FIGURE 2a. Photograph of unbaited minnow traps along a mesh barrier to form a trap line in Mesachie Lake.

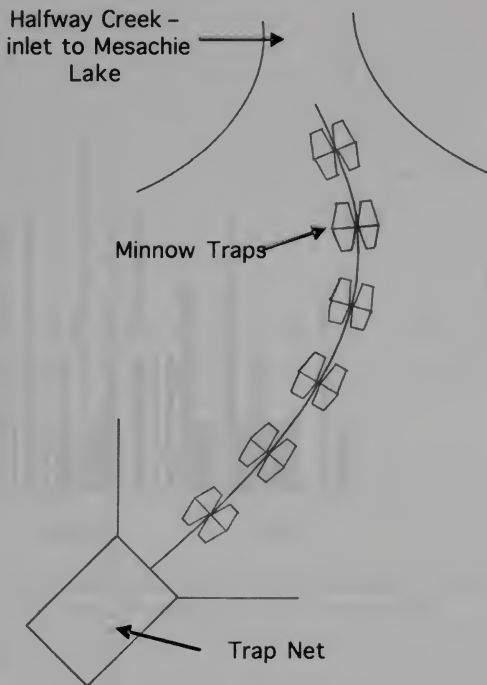


FIGURE 2b. Diagram of trap set-up at inlet of Halfway Creek to Mesachie Lake used in the 1980s. The set-up was similar in 2008 except a trap net was not used.

Catches were evenly spread out in May and June, with slightly smaller catches in July and up to mid-August. Male lampreys ($n=83$) averaged 211 mm (range from 179 mm to 272 mm) and 41 female lampreys averaged 204 mm (range from 182 mm to 256 mm) (Figure 4). In 1981, the trap net at the offshore end of the barrier fence was not used and minnow traps were in place from 18 April to 25 July. Catches of *L. macrostoma* from 16 May to 23 July totalled 21 mature lampreys (Figure 5). The traps were in place at the mouth of the Roberston River in 1981 from 9 June to 29 July. A total of 26 mature *L. macrostoma* were captured from 15 June to 21 July (Figure 5). Most lampreys were captured in mid-June (Figure 5). Lamprey spawning nests were distinguishable in the gravel area by circular areas of "cleaned" gravel about 6-12 cm in diameter. New spawning nests were commonly observed in June in both trapping areas.

Surveys of Lampreys in the Cowichan River

Ammocoetes of *L. richardsoni* and *L. tridentata* were common in the Cowichan River. In October 1988, recently metamorphosed *L. tridentata* and *L. richardsoni* were also captured. Ammocoetes of *L. tridentata* and *L. richardsoni* averaged 88 mm (43 mm to 125 mm) and 126 mm (46 mm to 187 mm), respectively (Figure 6). Recently metamorphosed *L. tridentata* averaged 110 mm (93 mm to 145 mm) and *L. richardsoni*

167 mm (163 mm to 171 mm) (Figure 6). The ammocoetes we identified as *L. tridentata* could not be distinguished from *L. macrostoma* ammocoetes, but none of the recently metamorphosed lamprey were *L. macrostoma*.

Coho Salmon Study

From 1988 until 1996, 342 lampreys were recorded in the downstream and upstream traps. All but six were recorded in the downstream traps. There were 59 lampreys identified as metamorphosed and 29 as ammocoetes. However, it is possible that more were metamorphosed, as many observations were labelled only as "lamprey". Most of the metamorphosed lampreys were identified as *L. macrostoma* and a few were identified as *L. tridentata*. There were six lampreys recorded in the upstream end trap. All were metamorphosed. Two were labelled as *L. tridentata*. Thus, 253 lampreys were recorded only as "lamprey". Coho Salmon smolts frequently had lamprey wounds and scars. For example, from 6 April to 30 June 1987, 1850 Coho Salmon smolts were examined in the downstream traps and 629 Coho Salmon smolts (34%) had at least one lamprey scar.

Recent Study and Report of Shoreline Development

No lampreys were caught in the traps at the junction of the outlet (Mesachie Creek and Mesachie Lake)

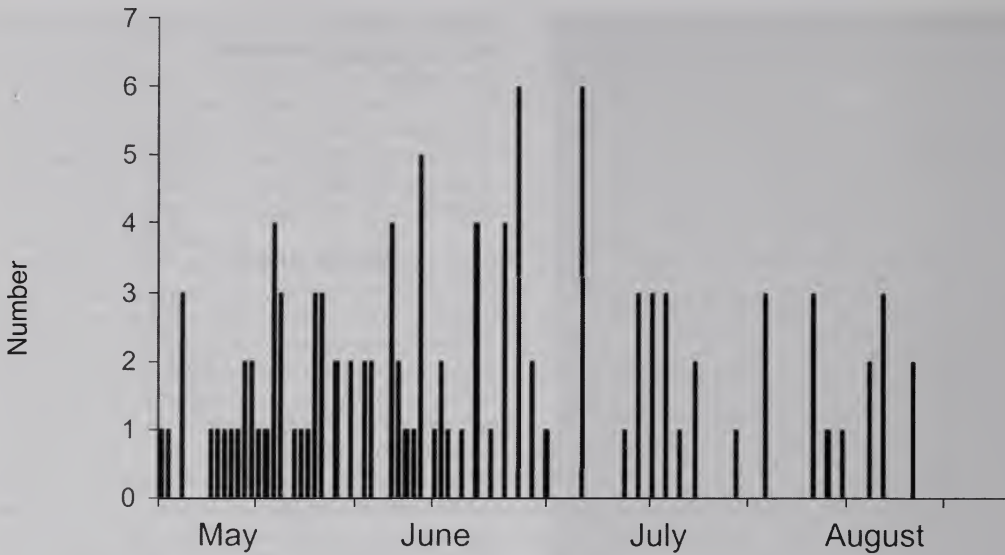


FIGURE 3. Number of mature and maturing *L. macrostoma* caught in traps in Mesachie Lake in 1980. Vertical lines indicate the number of lamprey caught in each day.

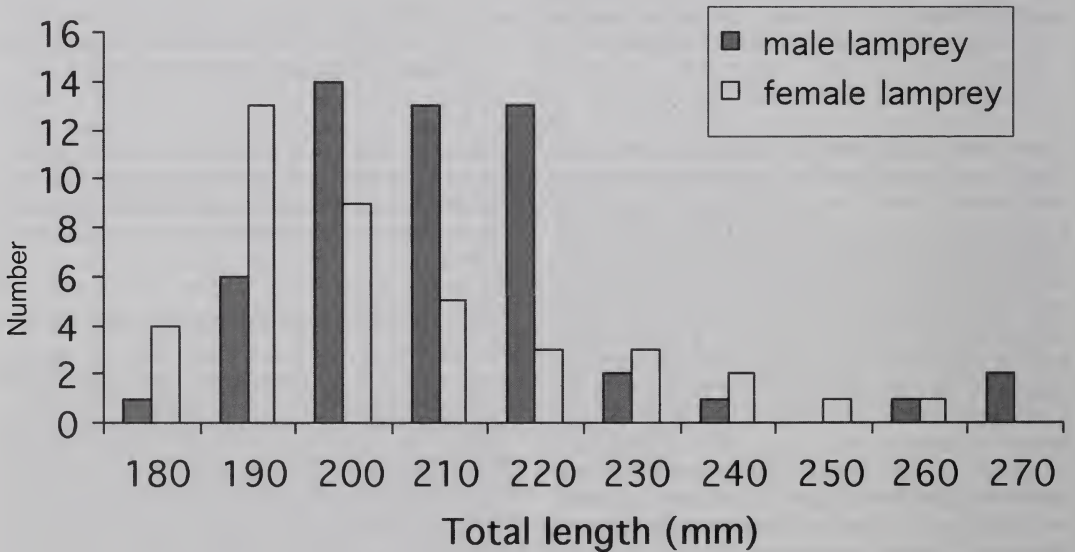


FIGURE 4. Length frequency of male and female *L. macrostoma* caught in 1980 in Mesachie Lake.

during the spring/summer of 2008. Four *L. macrostoma* were caught in the traps at the gravel area adjacent to the inlet of Halfway Creek. Other species in the traps included: Cutthroat Trout (*Oncorhynchus clarki*), stickleback (unidentified), sculpin (unidentified) and crayfish (unidentified) (Table 2).

The substrate in the area of Mesachie Creek is mostly mud and therefore not ideal for lamprey spawning which may be the reason we did not catch any lampreys in this area in our recent study or in the previous study. The substrate at the junction of the inlet stream, Halfway Creek and Mesachie Lake in 2008 was ap-

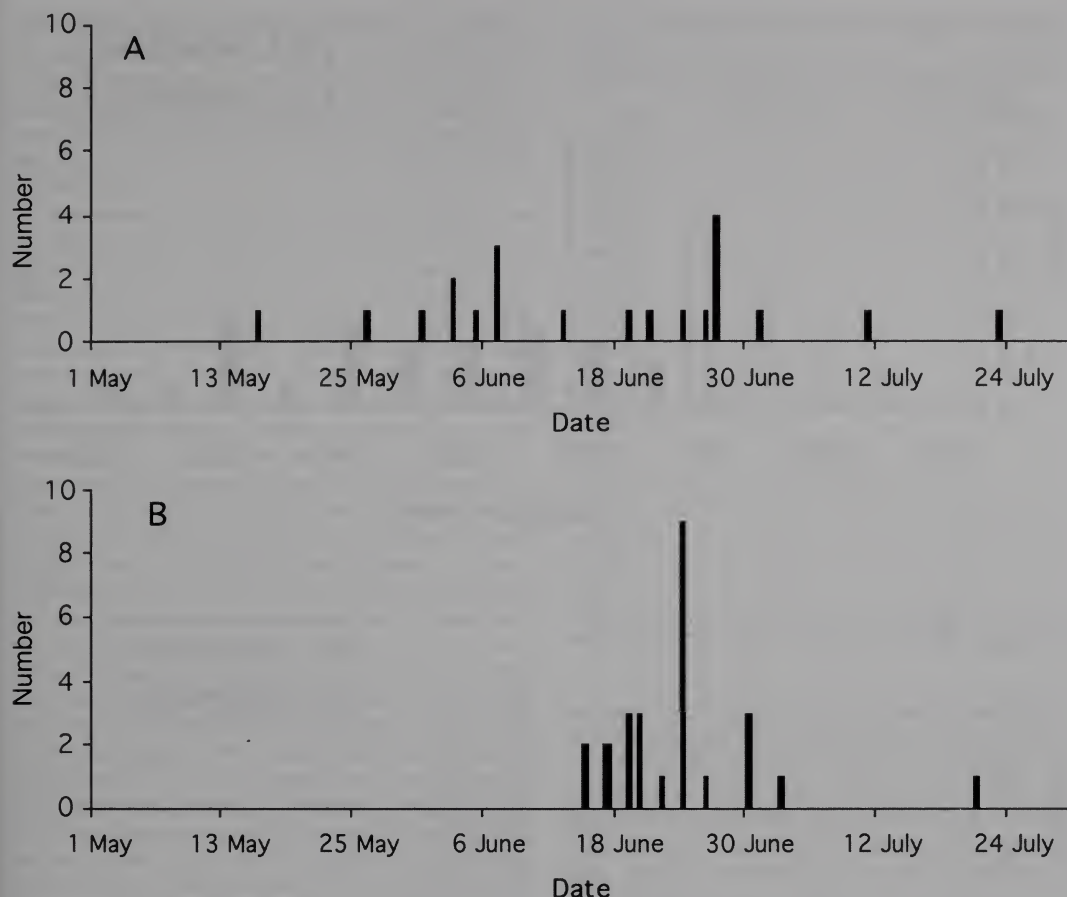


FIGURE 5. *L. macrostoma* catches from Mesachie Lake (A) and the mouth of Robertson River (B) in 1981.

proximately equal amounts of small gravel, fine substrate and large gravel. The critical rearing habitat is characterized by layers of fine silt and fine gravel. It does not appear that this substrate has changed since studies in the early 1980s.

We observed that there has been significant development on Mesachie Lake in the past fifteen years. There are two new houses close to the spawning area at the inlet stream. One property appears to extend up to the inlet stream itself. The other property is within 50 m of the spawning area. There has been no development along the main road on the south-west side of Mesachie Lake in the past fifteen years. Due to the geology of the lake there has been no development on the north-east side of the lake. This side remains as it was in the early 1980s, with a sheer rock cliff that drops into the water. Because of this abrupt drop-off, there are no beaches or potential spawning grounds in this area.

The area of the lake where the outlet stream is located has undergone significant development since the

1980s. Houses and cottages have been built along with Camp Imadene. Camp Imadene is a new facility (first campers in 1992) and is located at the former site of the Hillcrest Lumber Company. Camp Imadene currently owns 55 acres around Mesachie Lake and it is believed that they own the rights to the lakebed. New residents along the lakeshore have cleaned out the riparian zone over much of this area and brought in fine gravel to create beaches. The new "beaches" created by landowners may provide potential spawning areas because of the addition of fine substrate to the foreshore; however, trapping studies were not conducted on these beaches in 2008.

Most of the houses and the large camp have their own docks and boats and some residents live at the lake all year. Through conversations with long time residents along the lake, it is clear that there is significant activity on the lake during the summer. There are many boaters and fishermen, in particular there seems to be significant activity from the camp with numerous boats

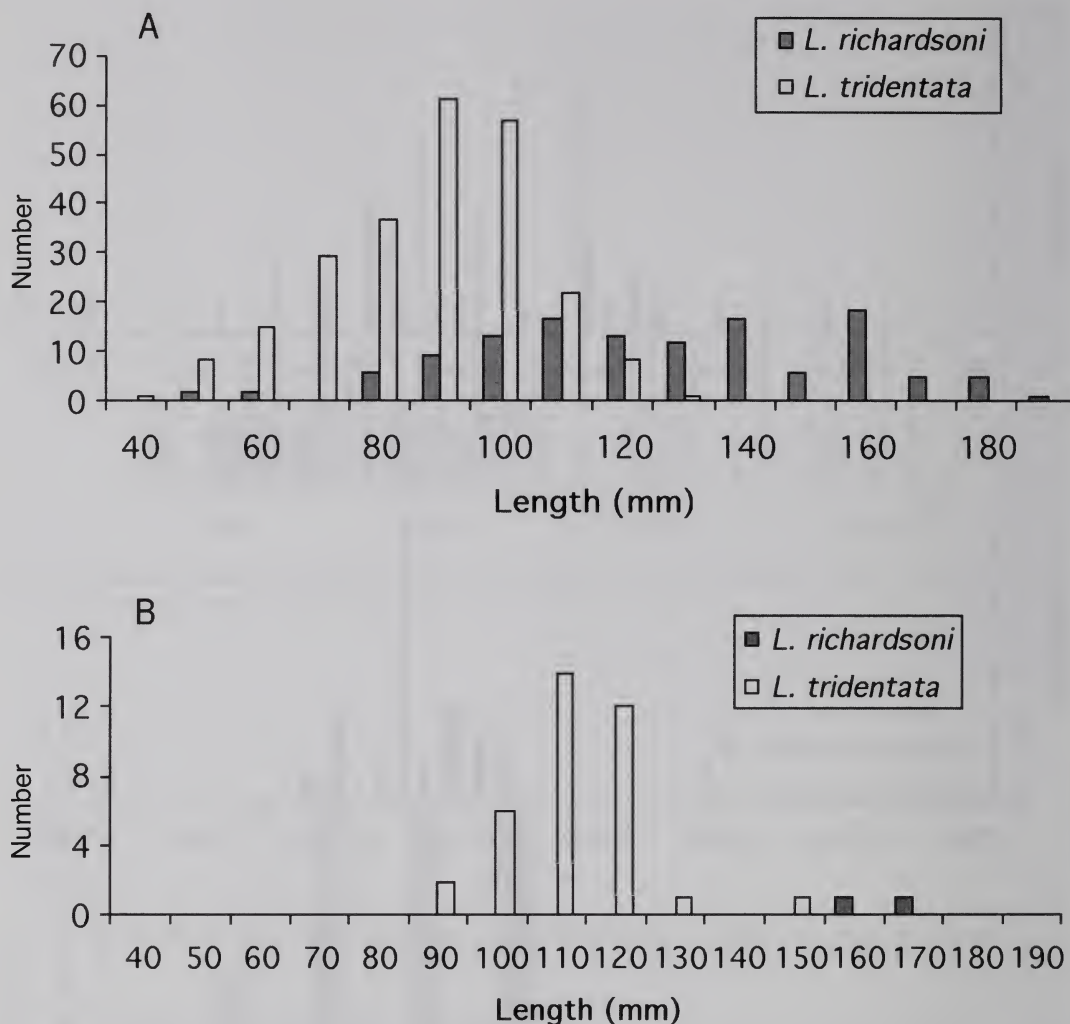


FIGURE 6. (A) Length frequency of *L. richardsoni* ammocoetes ($n=126$) collected in July 1985 ($n=30$), September 1985 ($n=7$) and October 1988 ($n=89$) and *L. tridentata* ($N=239$) ammocoetes collected in July 1985 ($n=24$), September 1985 ($n=85$) and October 1988 ($n=130$). (B) Length frequency of recently metamorphosed *L. richardsoni* ($n=2$) collected in September 1985 and *L. tridentata* ($n=36$) collected in September 1985. The data are presented only to indicate that the lamprey were present.

and boating activities on the lake. It is not known what impact these new activities have had or will have on the lamprey population in Mesachie Lake or on lamprey prey.

The year of our recent study (2008) marked the 30th anniversary of a children's fishing derby on Mesachie Lake. Accurate records have not been kept, but long-time residents Mr. and Mrs. E. Pawlik have hosted the derby each year. They observed that the catches related to effort have been decreasing dramatically in the last few years.

Discussion

Critical Habitat

The critical habitat for the conservation of *L. macrostoma* is the shallow covered gravel areas near the mouths of rivers and streams that flow into Mesachie and Cowichan lakes. It is possible that flows from these rivers are also important during the egg incubation stage. Substrate was approximately equal amounts of silt, small gravel, fine substrate and large gravel. Fine sediment on top of small gravel was the most common habitat, but ammocoetes were also found in areas with

fine woody debris on top of firm sediment. In general, this was typical habitat for many species of lamprey (Hardisty and Potter 1971b). Substrate deeper than approximately 1 m was rarely sampled, but when sampled, few lamprey were found, probably indicating that the deeper areas are not major rearing areas for ammocoetes.

Ammocoete age is difficult to determine despite the attempts to use statoliths (Volk 1986; Beamish and Medland 1988) or lengths (Potter 1980; Beamish and Medland 1988) resulting in most authors repeating published estimates that were originally interpretations based on a length frequency analysis. If we assume ammocoete ages are similar to those reported by other authors (Potter 1980; Beamish and Medland 1988), then the ammocoetes may be about five years old or older when they metamorphose into the adult stage. This would indicate that the rearing habitat for the ammocoetes must remain in a natural state for long periods.

The areas containing larger concentrations of ammocoetes are also important spawning areas. We speculate that the flow from the inlet stream into the lake and over the spawning area is important. In years such as 1983 when there was very little water flow into Mesachie Lake the sand and gravel area is uncovered and lamprey spawning appears to be restricted. At these times the gravel bar in Mesachie Lake would be approximately 30 m in length and 2 m across at its widest point. Thus, even though the river bottom of inlet streams may not be an important rearing area, the flow from the stream may be important over the protracted spawning period. Lake level is also important as the shallow spawning areas can become restricted in size if lake levels are low from early May to the end of July. We have not observed *L. macrostoma* building nests, spawning or holding in the vicinity of the spawning area. Thus, we suspect that spawning may occur at night and that these lake spawning lamprey do not have a spawning behaviour like many lamprey that spawn in rivers (R. Beamish, personal observations). We have not compared the timing and duration of spawning of *L. macrostoma* with *L. tridentata* that spawn in the Cowichan River. However, biologists employed at a hatchery on the Cowichan River reported that *L. tridentata* that average about 35 cm in total length spawn from about mid-April to late May. If these reports are accurate, it confirms that *L. macrostoma* has a different spawning time, spawning size and spawning behaviour than *L. tridentata* in the same watershed.

Other Species of Lamprey

We have not observed *L. tridentata* in Mesachie Lake or Cowichan Lake. We did collect *L. tridentata* in the Cowichan River and it is common to observe *L. tridentata* spawning in the Cowichan River. Adult Coho Salmon migrate into Mesachie Lake, so access to both Cowichan and Mesachie lakes to *L. tridentata* is possible. We interviewed local residents and no one

TABLE 2. Catches in the traps from the 2008 field sampling season.

Date	Inlet area <i>L. macrostoma</i>	Outlet area <i>L. macrostoma</i>
2 May	0	0
3 May	0	0
4 May	0	0
6 May	0	0
3 June	1	0
5 June	1	0
7 June	0	0
9 June	1	0
11 June	0	0
13 June	0	0
15 June	1	0
17 June	0	0
19 June	0	0
21 June	0	0
23 June	0	0
25 June	0	0
27 June	0	0
29 June	0	0
1 July	0	0
Total	4	0

reported observing lampreys spawning in rivers flowing into Mesachie or Cowichan lakes. If *L. tridentata* were spawning in the two lakes it is probable, that over many decades, local residents would know that lamprey were spawning in the rivers. Thus, we speculate that if *L. tridentata* enter the lakes, it is uncommon. We therefore conclude that it is probable that all of the ammocoetes found along the shoreline of both lakes in our surveys were *L. macrostoma*.

It is important to confirm if adult *L. tridentata* move into Cowichan Lake from the Cowichan River. If it is confirmed that *L. tridentata* do not migrate into Cowichan Lake, it may appeal to the curious to determine why a species that is known to be capable of migrating approximately 500 km (Farlinger and Beamish 1984) does not migrate the relatively short distance into Cowichan Lake. A possible explanation may relate to the availability of spawning areas in the rivers flowing into Cowichan Lake.

Records from the Coho Salmon study list a few *L. tridentata* in the traps but no specimens were saved and all identifications were made without measurements or any recorded documentation. Thus, it is probable that all metamorphosed lampreys in the Coho Salmon study were *L. macrostoma* and not *L. tridentata*.

The Coho Salmon study did show that lampreys are moving out of Mesachie Lake. The stage of development was not recorded for many lampreys, but the size indicated that these lampreys were a mixture of ammocoetes and metamorphosed lampreys. The few lamprey in the upstream traps were all metamorphosed and could be individuals moving back into Mesachie

Lake that were captured in the downstream trap and released on the downstream side. Alternatively, they could be migrating into the lake. However, the numbers were very small and the recorded sizes were in the range of sizes observed for *L. macrostoma* and not mature *L. tridentata* in general (Beamish 1980) or mature *L. tridentata* that spawn in the Cowichan River in late April and early May.

It is important to recognize that *L. macrostoma* is distinct from *L. tridentata*. *L. tridentata* is commonly found in many rivers and streams in British Columbia (R. Beamish unpublished survey data). Thus, there are probably hundreds of populations of *L. tridentata* in British Columbia. There are only a few *L. tridentata* populations that have been reported to feed in fresh water. One in Elsie Lake (Beamish and Northcote 1989) was shown to result from the construction of a dam that prevented the metamorphosed individuals from leaving the lake. It was reported that the metamorphosed lamprey fed only a short time and died. Adult lampreys were also prevented from entering Elsie Lake and it appears that the population was extirpated. Thus, although there was some feeding, the population was unable to reproduce. There are freshwater feeding *L. tridentata* in two other lakes in British Columbia (R. Beamish, personal communication). Neither of these populations are *L. macrostoma*. One population in Sakinaw Lake (49°40'N, 124°00'W) consists of an anadromous form and a possible non-anadromous form, but neither form has been studied in detail. It is known from morphometric measurements that the freshwater parasitic form is not *L. macrostoma* (R. Beamish, unpublished data). The other known population is from West Lake on Nelson Island (49°44'N, 124°05'W). Specimens from this population are not *L. macrostoma*, although they differ slightly from *L. tridentata*. It is possible that if new species of lampreys can evolve in the past 10 000 years as reported earlier, there will be some variation among existing populations of a wide ranging species such as *L. tridentata*. This variation, which we know only from two other populations, is not sufficient to ignore the differences between *L. macrostoma* and *L. tridentata*. Thus, it is important to maintain the species distinction of *L. macrostoma* and to recognize the importance of protecting its habitat and its ecology.

Conservation Ecology

Beamish (1982) reported that feeding adult *L. macrostoma* in Mesachie Lake readily attacked resident fishes. Up to 50% of potential prey species collected in the trap net in 1980 had some evidence of being attacked by lamprey. Carl (1953) reported that 8 of 10 fish examined from Cowichan Lake had been attacked by lamprey. Local residents reported that fish in general and Cutthroat Trout in particular in Cowichan and Mesachie lakes are often scarred by lamprey. Less commonly, fish are landed with lamprey still attached.

All lamprey specimens that we have examined that were attached to fish caught by anglers were *L. macrostoma*. The Coho Salmon study and an earlier study (Beamish 1982) showed that Coho smolts leaving Mesachie Lake were heavily scarred, indicating that juvenile Coho were an important prey of *L. macrostoma*. There are no estimates of the abundance of species such as Cutthroat Trout that are a common prey of *L. macrostoma*. It is known that wild Coho Salmon abundance in the areas around the Strait of Georgia (Figure 1) has declined dramatically (Beamish et al. 2008). Thus it is probable that juvenile Coho Salmon that rear in the lakes for one or two years are also in lower abundance in recent years. We received reports that catches of sport fish were declining and the development around Mesachie Lake indicates that fishing effort probably has increased. We are concerned that our trapping study in 2008 captured only four *L. macrostoma*. This is a much smaller catch than in 1981, when the trapping design at the inlet of Mesachie Lake was similar. Unfortunately, it is not possible to estimate lamprey abundance from scarring rates as it is not known if a high scarring rate is a consequence of reduced prey or increased lamprey abundance. If *L. macrostoma* are to be protected, it is necessary to determine the population size as quickly as possible. A standard mark and recapture study is needed to estimate the adult abundance. This could be accomplished using trap nets and marking the lamprey before and during the spawning period with latex injections into the dorsal fin fold. It is also important to ensure that prey species in the lake are not overfished. Until the abundance of *L. macrostoma* is known, it is important to restrict any lethal sampling of ammocoetes or adults of *L. macrostoma*. The impact of the recent shoreline development around Mesachie Lake also needs to be assessed.

Acknowledgements

The authors acknowledge the unwavering interest and enthusiasm of Mr. Ed Pawlik for our project and for *L. macrostoma*, Wendy Mitton and Mike Smith for their many years of support for the lamprey program and for their shocking assistance in the Mesachie and Cowichan lakes study. Thank you to Steve Baillie for the Coho Salmon study data. Thank you to Lana Fitzpatrick for her assistance in the preparation of this manuscript.

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A Range Extension of the Atlantic Silverside, *Menidia menidia*, to Coastal Waters of Southwestern Newfoundland

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Previous literature documents Atlantic Silverside, *Menidia menidia*, as occurring from the southern Gulf of St. Lawrence to northeastern Florida. Beach seining in St. George's Bay, Newfoundland, revealed the presence of this species in coastal waters of southwestern Newfoundland. This is the first documented report of *M. menidia* in Newfoundland waters. This report extends the range of this species north of the Laurentian Channel, a significant biogeographic barrier to small coastal fishes. All *M. menidia* collected were young-of-the-year, less than 90 mm SL (Standard Length). These fish may be representative of a larger relict population originating from the Mid-Hypsithermal Interval (7000 years ago) that spawn in St. George's Bay and migrate offshore for winter. Alternatively, these *M. menidia* may be survivors of a more southern spawning population carried northward by ocean currents.

Key Words: Atlantic Silverside, *Menidia menidia*, species distribution, range extension, Newfoundland.

Beginning in autumn 2006, surveys were conducted along the coast of Newfoundland as part of the project "Early Detection and Monitoring of Aquatic Invasive Species in Newfoundland and Labrador in High Risk Areas". This project was part of the Government of Canada's *Action Plan to Address the Threat of Aquatic Invasive Species* (2005). Surveys were conducted collaboratively by representatives of the Federal Department of Fisheries and Oceans (DFO), Provincial Department of Fisheries and Aquaculture, and Memorial University's Ocean Sciences Centre. The objective was to determine the presence and abundance of non-native species in Newfoundland coastal waters, and whether these species pose ecological or economic threats in the province.

Materials and Methods

Surveys for this project included visual beach surveys, scuba surveys around public wharves, setting two or three baited crab pots from wharves, and one or more beach seines adjacent to wharves. One such survey was conducted on the southwest coast of Newfoundland in St. George's Bay on 18 October 2007. A scuba survey was taken at the public wharf in the community of St. George's (48°25'49.4"N; 58°29'04.1"W) and a beach seine was set just east of this wharf (48°25'54.3"N; 58°28'54.4"W; Figure 1).

The scuba survey involved a visual survey of the wharf structure and surrounding habitat for non-native organisms. Habitat and environmental conditions of the area were noted. The beach seine used for this project was the same as that described in Laurel et al.

(2003) with the exception that a 10 mm stretched mesh liner was sewn into the bag of the net (excluding the cod end). The seine, deployed perpendicular to shore by a 4 m Mark II Zodiac, sampled more than 800 m² of habitat from the substrate to 2 m into the water column (Laurel et al. 2003). The catch was transferred to a plastic commercial "fish box" (80 cm L × 47 cm W × 30 cm H) with seawater and each species was identified, counted and returned alive to the seine site. Unidentified species were retained and preserved in plastic sample jars with 10% formalin added to seawater for later identification. Fish species were identified based on descriptions presented in Scott and Scott (1988) and Able and Fahay (1998).

Results

Fishes captured in the beach seine set in St. George's are listed in Table 1. Eight specimens of Atlantic Silverside, *Menidia menidia* (Linnaeus 1766; Figure 2), were captured, of which three were preserved for confirmation of species identification. Counts of dorsal and anal fin rays (Table 2) identified these specimens as *M. menidia* and distinguished them from *M. beryllina*.

In St. George's, shoreline substrate consisted primarily of gravel with *Fucus* sp. on small rocks near shore, and patches of Eelgrass, *Zostera marina*, further from shore. At 3 m, approximately the maximum depth sampled by the beach seine, water temperature was 5°C and the upper 2 m was primarily freshwater with a distinct boundary layer, as observed during the scuba survey conducted at the public wharf.

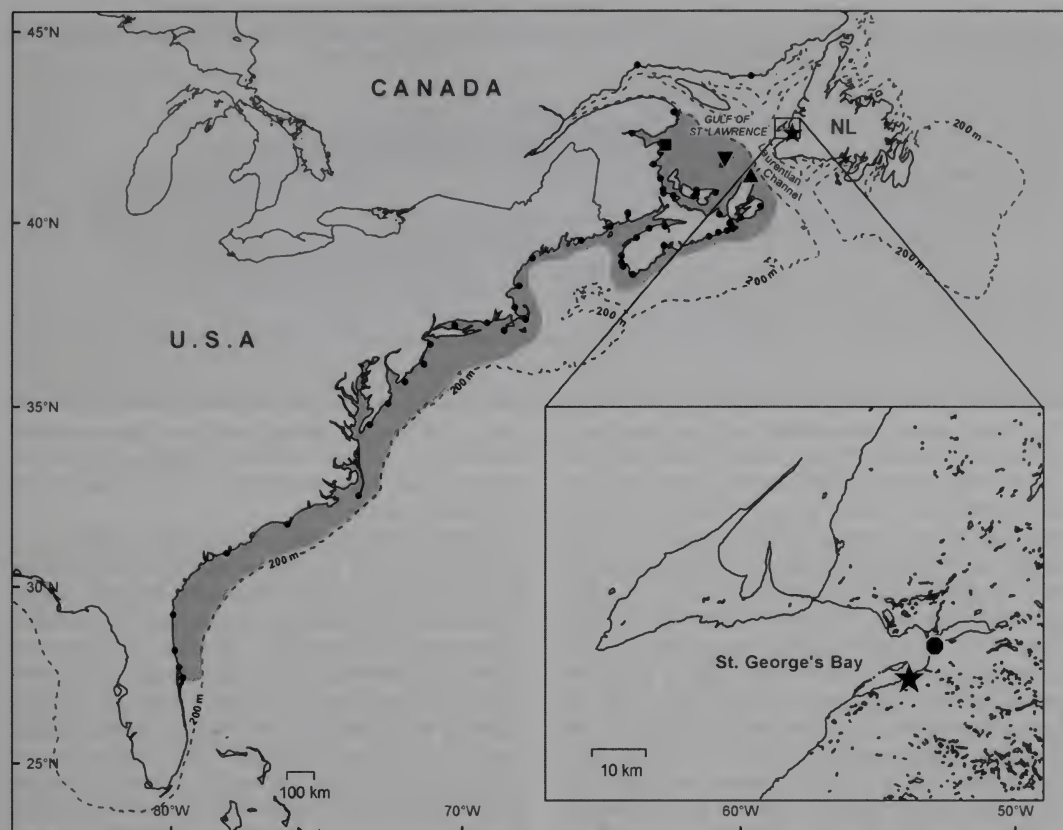


FIGURE 1. Map of Eastern North America. Shaded area indicates the current distributional range of Atlantic Silverside, *Menidia menidia* within the 100m isobath (excluding Georges Bank and the Scotian Shelf) based on data from the following sources: Cox 1921; Squires and Gorham 1967; Johnson 1975; Weinstein et al. 1980; Gilmurray and Daborn 1981; Conover and Murawski 1982; Jessop 1983; Johnston and Morse 1988; Moring 1990; Hanson and Courtenay 1995; DFO 2007; Thériault et al. 2006, 2007; O'Connor 2008; DFO-FSRS Inshore Ecosystem Project, unpublished data; S. Courtenay and P. Nellis, personal communications. ▲ – Bay St. Lawrence, Cape Breton, Nova Scotia and ▼ – Île du Havre aux Maisons, Magdalen Islands, Quebec; – the closest known reports of *M. menidia* to St. George's ■ – Lamèque Bay, New Brunswick – the previous most northern literature report for *M. menidia*.

Insert is an expanded view of St. George's Bay. ● – observations of *M. menidia* from the sources above; ★ – St. George's, where *M. menidia* specimens were captured in this study (48°25'54.3"N; 58°28'54.4"W). ● – Stephenville Crossing, where *M. menidia* were also captured (48°29'06.20"N; 58°25'06.60"W). Data points outside the shaded region (including those in St. George's Bay and the northern Gulf of St. Lawrence) indicate areas where breeding populations have yet to be confirmed.

The *M. menidia* specimens were deposited in The Rooms, Provincial Museum of Natural History Annex, 9 Bonaventure Avenue, P.O. Box 1800, Stn. C, St. John's, Newfoundland and Labrador A1C 5P9 Canada, under Catalogue # PI-44.

Discussion

The Atlantic Silverside, *Menidia menidia*, is a schooling species common in brackish marshes, intertidal creeks, and estuaries along coastal waters of the western Atlantic from the southern Gulf of St. Lawrence to northeastern Florida during summer and au-

tumn (Johnson 1975; Scott and Scott 1988; Collette and Klein-MacPhee 2002; Figure 2). *Menidia menidia* is most similar to Inland Silverside, *M. beryllina*, with which it co-occurs from southern Massachusetts to northeastern Florida (Johnson 1974). Counts of dorsal and anal fin rays (Table 2) distinguish these two species and identified the specimens collected in St. George's as *M. menidia*.

Menidia menidia is reported to be an annual species completing its life cycle in one year (Conover and Murawski 1982), although populations near its northern limit apparently have a larger proportion surviving

TABLE 1. Fishes taken by beach seine at St. George's (48°25'54.3"N, 58°28'54.4"W) on 18 October 2007.

Common Name	Species Name	Number Caught
Sand Lance	<i>Ammodytes</i> sp.	1
Fourspine Stickleback	<i>Apeltes quadracus</i>	Many (not counted)
Threespine Stickleback	<i>Gasterosteus aculeatus</i>	Many (not counted)
Atlantic Tomcod	<i>Microgadus tomcod</i>	26
Atlantic Silverside	<i>Menidia menidia</i>	8
Sculpin (small)	<i>Myoxocephalus</i> sp.	1
Rainbow Smelt (juvenile)	<i>Osmerus mordax</i>	1
Winter Flounder	<i>Pseudopleuronectes americanus</i>	2
Cunner (juvenile)	<i>Tautoglabrus adspersus</i>	16
White Hake (juvenile)	<i>Urophycis tenuis</i>	2

to age-2 than southern populations (Jessop 1983). Typically, adults move into estuaries and salt marshes in April or May (Jessop 1983), spawn between May and July (Needler 1940; Cadigan and Fell 1985), and decline in abundance during summer (Cadigan and Fell 1985) before returning to sea between July and October (Jessop 1983). Young-of-the-year begin migrating out of the estuary in September (Jessop 1983), by which time they can grow to 130 mm (total length) (Able and Fahay 1998), depending on location (e.g., Jessop 1983; Rountree and Able 1992; Able and Fahay 1998) and time of hatching (Cadigan and Fell 1985). This off-shore migration may be in response to potential stressful and/or lethal water temperatures in shallow estuarine waters during winter (Conover and Murawski 1982). There are exceptions, however, as some individuals remain in estuaries throughout the winter (Collette and Klein-MacPhee 2002) and have even been taken through the ice in Malpeque Bay, Prince Edward Island (Needler 1940). *Menidia menidia* specimens retained from St. George's (Table 1) were some of the smallest captured in the beach seine, none of which measured more than 90 mm standard length (SL). Based on size and time of capture, specimens appear to be young-of-the-year that had yet to migrate to off-shore waters or other parts of St. George's Bay, where they may overwinter. Young-of-the-year *M. menidia* in St. George's Bay suggests a local spawning population may occur nearby. Alternatively, *M. menidia* may be survivors from a more southern spawning population that were transported northward into St. George's Bay by ocean currents. Some species may be found in areas where they do not normally reproduce, being trans-

ported as larvae by ocean currents (Markle et al. 1980; Steele 1983) or are summer visitors to Newfoundland waters (e.g., Atlantic Mackerel, *Scomber scombrus*, Bluefin Tuna, *Thunnus thynnus*, various sharks, and cetaceans) (Steele 1983).
Observed habitat and environmental conditions at St. George's were consistent with those preferred by *Menidia menidia*, as described in the literature. Salinity tolerances for this species range from 23.8 – 32.2‰ (Briggs and O'Connor 1971). Barker (1993) reported salinity in November 1992 at St. George's varied from 23.0‰ at the surface to 31.1‰ at 6 m depth. *Menidia menidia* occur closer to the bottom during daylight hours (Conover and Murawski 1982). Given that our seining was conducted during the day and that a distinct boundary was observed between the upper and lower saltwater layers, specimens collected at this site likely occurred in the lower, more saline layer. Specimens at St. George's were collected at 5°C water temperature. Temperature tolerances for this species range from 2.2 – 29.4°C (Briggs and O'Connor 1971) but occur most often between 2 and 6°C (Conover and Murawski 1982). *Menidia menidia* is found frequently in large numbers over sand, gravel (Scott and Scott 1988; Able and Fahay 1998), mud, or peat substrates (Collette and Klein-MacPhee 2002) at depths < 50 m (Conover and Murawski 1982). Young-of-the-year *M. menidia* are most abundant at depths of 1 to 3 m over sandy substrates and where complex habitat includes Eelgrass (Able and Fahay 1998; Mattila et al. 1999). Smaller individuals are found in larger proportions over vegetated habitats (Briggs and O'Connor 1971). *Menidia menidia* use estuarine environ-

TABLE 2. Standard lengths (mm) for *M. menidia* captured at St. George's (48°25'54.3"N, 58°28'54.4"W) and their fin ray counts compared with differential characteristic fin ray counts (spines are Roman numerals; soft rays are Arabic numerals) of *Menidia beryllina* and *M. menidia* (as described by Able and Fahay 1998).

Characteristic	<i>M. beryllina</i>	<i>M. menidia</i>	Specimen #1	Specimen #2	Specimen #3
SL (mm)	—	—	51	56	58
1 st Dorsal	V	III – VII	VI	VI	VI
2 nd Dorsal	6 – 8	7 – 11	10	9	9
Anal	16 – 19	19 – 29	25	23	26

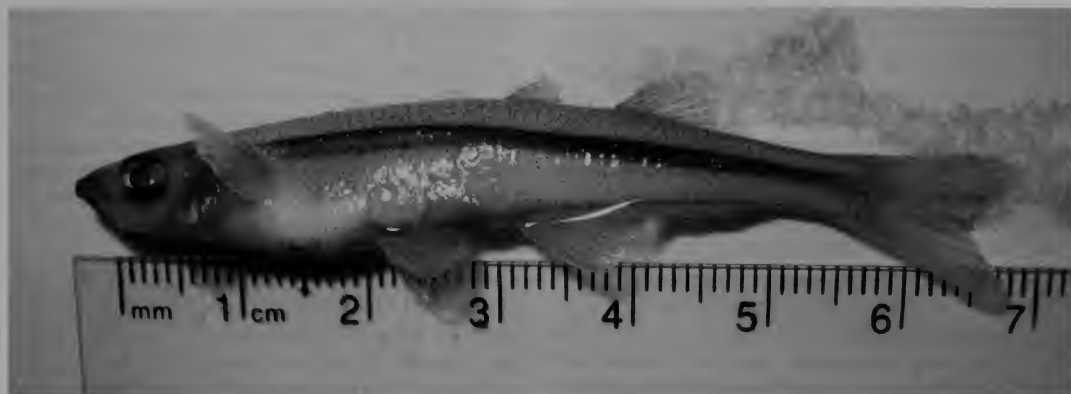


FIGURE 2. Atlantic Silverside, *Menidia menidia*, specimen collected from St. George's (48°25'54.3"N, 58°28'54.4"W) on 18 October 2007.

ments as spawning sites and feeding sites for juveniles and adults during warmer months (Cadigan and Fell 1985). Vegetated areas within these environments act as nurseries for young-of-the-year (Briggs and O'Connor 1971; Cadigan and Fell 1985; Able and Fahay 1998).

Collection of *Menidia menidia* in St. George's Bay, constitutes a range extension for this species to coastal Newfoundland waters that are northeast of the Laurentian Channel. The Laurentian Channel is > 400 m deep (Curry 2007) and is a geographic barrier separating the Scotian Shelf and Newfoundland Shelf marine ecosystems (Mahon et al. 1998). Though not a significant barrier to demersal fish species (Mahon et al. 1998), the Laurentian Channel may be a barrier to *M. menidia* that are confined to coastal waters (Scott and Scott 1988) to a maximum depth of 126 m (Conover and Murawski 1982).

In Atlantic Canada, *Menidia menidia* occurs throughout the southern Gulf of St. Lawrence region (Johnson 1975; Scott and Scott 1988; Collette and Klein-MacPhee 2002). Reports of *M. menidia* in this region include the Bay of Fundy (Squires and Gorham 1967; Gilmurray and Daborn 1981; Jessop 1983; O'Connor 2008), the east and southeast coasts of Nova Scotia (O'Connor 2008), off Cape Breton (Cox 1921; DFO 2007; DFO-Fishermen and Scientists Research Society (FSRS) Inshore Ecosystem Project, unpublished data), Prince Edward Island (Needler 1940; Johnston and Morse 1988; Thériault et al. 2006), Magdalen Islands (Cox 1921; P. Nellis, personal communication), along the Northumberland Strait (Thériault et al. 2006, 2007), Mirimichi Estuary (McKenzie 1959; Hanson and Courtenay 1995), Chaleur Bay (Thériault et al. 2006; S. Courtenay, personal communication) and Gaspé Bay (P. Nellis, personal communication). Along central and eastern coasts of Prince Edward Island there has even been a moderate commercial fishery since 1973, mostly for young-of-the-year fish (Cairns 1997). The closest locations

from St. George's (in linear distance), for which *M. menidia* has been previously reported, are Bay St. Lawrence (Deadman's Pond), Cape Breton, Nova Scotia (Cox 1921) (220 km) and Île du Havre aux Maisons, Magdalen Islands, Quebec (Cox 1921) (265 km). In September 2008, small numbers of *M. menidia* were captured on the north side of the Gulf of St. Lawrence at Havre Bluff and Sept-Îles, Quebec (J-D. Dutil and P. Nellis, personal communications) (see Figure 1). All *M. menidia* from the northern Gulf of St. Lawrence were less than 60 mm total length (P. Nellis, unpublished data) and were likely juveniles. *Menidia menidia* were not observed at sites surveyed along the St. Lawrence River (P. Nellis, personal communication).

Menidia menidia has not been previously reported from coastal Newfoundland (Squires 1951; Scott and Crossman 1964; Templeman 1966; Gregory et al. 1997; Methven et al. 2001; I. Bradbury, personal communication) and Labrador (Backus 1957; Wroblewski et al. 2007). There are no records of specimens in the Newfoundland Provincial Museum of Natural History (R. Batten, personal communication) other than the three specimens deposited from this study. Johnson (1975) did state that *M. menidia* is found as far north as Newfoundland but provided no supporting data. *Menidia menidia* were captured by beach seine at Stephenville Crossing (48°29'13.5"N, 58°25'6"W), less than 10 km from the seine site in St. George's, on 11 July 1973 (R. Hooper, unpublished data) but this information has not been reported until now. Subsequent beach seining at Stephenville Crossing (48°29'06.20"N, 58°25'06.60"W) on 7 September 2009, resulted in 24 juvenile *M. menidia* (37 – 66 mm SL) being collected in approximately the same area R. Hooper collected them 36 years earlier. The northeast portion of St. George's Bay may therefore contain a previously undescribed spawning population.

Species distributions are often disjunct and discontinuous in coastal areas from Labrador to southern New England (Bousfield and Thomas 1975; Hooper et al. 2002). Warm-water species typically require relatively high water temperatures for reproduction and/or growth and reproduce in late spring and summer (Bousfield and Thomas 1975). As a result, many warm-water species have restricted distributions in Atlantic Canada (Bousfield and Thomas 1975; Steele 1983; Hooper et al. 2002), which appears consistent with *Menidia menidia* (Needler 1940; Cadigan and Fell 1985). As explained by Bousfield and Thomas (1975), during the Mid-Hypsithermal period (7000 BP), mean water temperatures were 2.5°C higher than those today, and warm-water fauna distributions were continuous throughout the Gulf of St. Lawrence to New England. Furthermore, through to the Post-Hypsithermal period (3000 years ago), as sea levels continued to rise, outer coastal margins sank and shorelines rose, warm-water and coastal marine fauna became isolated from populations in the south. Current warm-water regions are restricted to the southern portion of the Gulf of St. Lawrence, the head of the Bay of Fundy, and south of Cape Cod, with pockets in western Nova Scotia, the Magdalen shallows, and southwestern Newfoundland (Bousfield and Thomas 1975; Steele 1983).

Global climate fluctuations have resulted in changes to species distributions (Bousfield and Thomas 1975; Steele 1983; Hewitt 2000). Some species became extinct in parts of their range, dispersed into new regions, or survived in refugial areas, later expanding their distribution when climatic conditions again changed (Hewitt 2000). *Menidia menidia* in St. George's Bay may represent a relict population that existed throughout the Gulf of St. Lawrence region during the Mid-Hypsithermal period. Alternatively, the presence of *M. menidia* in St. George's Bay may represent a new introduction or recent recolonization of this region. A phylogeographic study of *M. menidia* by analysis of mitochondrial DNA from specimens collected throughout Atlantic Canada may confirm the long-term separation of a refugial population or else a possible reintroduction of this species into southwestern Newfoundland.

At least two other fish species found in St. George's Bay have distributions limited primarily to the south and southwest coasts of Newfoundland. The Eastern Banded Killifish, *Fundulus diaphonus diaphonus*, has only seven known, highly restricted, populations in Newfoundland waters (Chippett 2003*). With the exception of the Indian Bay watershed population, all populations are located on the south and southwest coasts of Newfoundland (Chippett 2003*), one of which was reported at Stephenville Crossing, St. George's Bay (Squires 1951). Mummichog, *Fundulus heteroclitus*, a species very similar to Eastern Banded Killifish, are restricted to the southwest corner of Newfoundland, having been found in Piccadilly Bay,

Port au Port Bay; just north of Port aux Basques; and the head of St. George's Bay (Scott and Crossman 1964). Comparable population disjunctions are known for marine benthic algae (Hooper et al. 2002) and invertebrates (Bousfield and Thomas 1975).

Discovery of *Menidia menidia* in St. George's Bay supports the Early Detection and Monitoring of Aquatic Invasive Species in Newfoundland and Labrador in High Risk Areas in detecting macrofaunal species previously unknown to exist in this province. Since its inception in 2006, this project has discovered two invasive colonial tunicate species previously unrecorded in Newfoundland and Labrador waters. In 2006, Golden Star Tunicate, *Botryllus schlosseri*, was found in several areas of northern Placentia Bay (Callahan et al. 2007). In 2007, *B. schlosseri* was also found in Hermitage, Fortune Bay, and Violet Tunicate, *Botrylloides violaceus*, was discovered in Belloram, Fortune Bay (Callahan et al. 2009; McKenzie et al. 2009). Further, the expansion in distributional range of European Green Crab, *Carcinus maenas*, has also been monitored since its discovery in Placentia Bay by local fishermen in 2007 (C. H. McKenzie, unpublished data).

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Dynamics of Peripheral Populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in Southern British Columbia

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The Great Basin Pocket Mouse (*Perognathus parvus*) and Western Harvest Mouse (*Reithrodontomys megalotis*) are two peripheral species occurring in the southern Okanagan Valley of British Columbia, Canada. Both species are listed as vulnerable to extirpation because of habitat loss, primarily due to conversion of natural habitat to agricultural uses and suburban expansion. Population dynamics of these two species were studied in three habitat types: old field, sagebrush, and pine forest. The Great Basin Pocket Mouse occurred at densities ranging from 12 to 28/ha in sagebrush habitats and at 2-8/ha in old fields and Ponderosa Pine forest. The Western Harvest Mouse occurred at variable densities up to 10/ha in old fields and up to 5/ha in sagebrush habitats. Mean number of lactating females for Great Basin Pocket Mice ranged from 4-8 in sagebrush, 1-5 in old fields and pine forests combined. Mean juvenile survival to adulthood ranged from 3.28 young Great Basin Pocket Mice per pregnant female in sagebrush, 4.67 in old field, and 1.82 in pine forest habitats. Mean juvenile survival to adulthood of Western Harvest Mice ranged from 1.46-1.72 young per female in old field and sagebrush habitats. Conservation of habitat features (high biomass and structural diversity of grasses and forbs) in linear habitats has the potential to maintain populations of Western Harvest Mice. The Great Basin Pocket Mouse needs features of sagebrush and old field habitats that need to be conserved as natural non-linear components in mosaics of natural and anthropogenic habitats. Both species could act as "indicators" of habitat integrity for a wide range of other vertebrate, invertebrate, and plant species in the Okanagan Valley.

Key Words: Great Basin Pocket Mouse, *Perognathus parvus*, Western Harvest Mouse, *Reithrodontomys megalotis*, old fields, population dynamics, reproduction, sagebrush habitat, conservation, dispersal, British Columbia.

A diverse group of terrestrial small mammals inhabits the intermontane grasslands and shrub-steppe rangelands of the Okanagan and Similkameen valleys of southern British Columbia, Canada. This ecological zone with its semi-arid habitats is unique within Canada and has many of the endangered species listed by the Species at Risk Act (SARA). According to Harper et al. (1993), there are species of vertebrates, invertebrates, and plants in the southern Okanagan that occur nowhere else in British Columbia, and some occur nowhere else in Canada. These authors reported that only 9% of the landscape was still in a relatively natural state to support this biodiversity because of habitat losses from agricultural (including cattle grazing), urban, and recreational developments.

There are two species within the small mammal community that are considered vulnerable: the Great Basin Pocket Mouse (*Perognathus parvus*); and the Western Harvest Mouse (*Reithrodontomys megalotis*). The subspecies *R. m. megalotis* is designated as of special concern by COSEWIC (2007*). On a provincial basis, the British Columbia Ministry of Environment has the Great Basin Pocket Mouse on the red list (endangered or threatened taxa) and the Western

Harvest Mouse on the blue list (species of special concern) (B.C. Conservation Data Centre 2007*). Both rodent species have peripheral ranges in the Okanagan and Similkameen valleys with much wider distributions in the United States. The Great Basin Pocket Mouse also occurs in the Kettle River and Thompson River valleys (Nagorsen 2005). A related subspecies of Western Harvest Mouse (*R. m. dychei*) has a very limited range in southern Alberta and is listed as endangered (COSEWIC 2007*).

The importance of these two species is linked to their status as indicators of the health and integrity of natural habitats and to the significance of peripheral populations for a species' ability to evolve new adaptations to changing environments (Hunter and Hutchinson 1994). As discussed by Lesica and Allendorf (1995), conservation of peripheral populations is likely beneficial to maintenance of the evolutionary process, but also protection of those environmental systems may generate future evolutionary diversity. Alternatively, Hoffman and Blows (1994) suggest peripheral populations may be prone to extirpation or hold little evolutionary potential due to low genetic variability.

The Great Basin Pocket Mouse is a semi-fossorial granivore that inhabits shrub-steppe habitats in the intermontane zone of western North America, in particular dry grassland and shrub associations on light-textured soils (O'Farrell et al. 1975; Verts and Kirkland 1988). Populations of Great Basin Pocket Mice in the United States seemed to have relatively stable populations from year to year with occasional high numbers in years of enhanced plant productivity (O'Farrell et al. 1975; Verts and Kirkland 1988). In British Columbia, Great Basin Pocket Mice are often sympatric with Western Harvest Mice: grassland-steppe composed of Big Sagebrush (*Artemisia tridentata*), Antelope-brush (*Purshia tridentata*), Bluebunch Wheatgrass (*Agropyron spicatum*), Prairie Sagewort (*Artemisia norvegica*), and Common Rabbitbrush (*Chrysothamnus nauseosus*) (Nagorsen 2005). Old fields and Ponderosa Pine (*Pinus ponderosa*) forest may also be used by Great Basin Pocket Mice (Nagorsen 2005). This species hibernates from mid-October to late March in the southern Okanagan Valley (Iverson 1967).

The Western Harvest Mouse inhabits various grasslands, edges (linear habitats), riparian habitats, and coastal salt marshes in western North America (Webster and Jones 1982). This rodent prefers habitats with abundant grass-dominated herbaceous vegetation (Kaufman and Fleharty 1974; Moulton et al. 1981; Kaufman et al. 1988). Populations of Western Harvest Mice in the United States exhibited a range of patterns of abundance from annual cycles (Brady and Slade 2004) to highly variable numbers (Skupski 1995) with a potentially strong negative interaction with vole (*Microtus* spp.) population peaks (Heske et al. 1984). In British Columbia, Western Harvest Mice may occur in shrub-steppe grasslands with abundant tall grasses such as Bluebunch Wheatgrass and shrubs such as Big Sagebrush and Antelope-brush (Nagorsen 1995*, 2005) and in old fields (Sullivan and Sullivan 2004). This species is active year-round.

The native habitat requirements of these two species seem to be reasonably well documented, as well as data on population patterns in southern parts of their respective ranges in the U.S. However, there is a dearth of information on the population dynamics and status of either species in British Columbia and how such data might relate to conservation of native habitats and biodiversity. In particular, relatively long-term (i.e., 3-5 years) population studies provide insights into species persistence and help identify those habitats (both natural and managed) that should be conserved. Although abundance is important, the demographic attributes of reproductive performance, recruitment, and survival may be more important than numbers to determine habitat quality for small mammals (Van Horne 1983). Thus, this study was designed to compare the population dynamics of Great Basin Pocket Mice and Western Harvest Mice in a variety of

habitats in the southern Okanagan Valley of British Columbia.

Materials and Methods

Study area

This study was located in the Okanagan Valley at the Pacific Agri-Food Research Centre, Summerland, British Columbia, Canada (49°34'N; 119°40'W). Three habitat types were examined: old field, sagebrush, and Ponderosa Pine forest, at an elevation range of 400-464 m and reasonably similar soil profiles. The old field sites were abandoned (≥ 25 years) hay fields dominated by Crested Wheatgrass (*Agropyron cristatum*) and Quack Grass (*A. repens*), with some Alfalfa (*Medicago sylvatica*) and herbs such as Yellow Salsify (*Tragopogon dubius*), Great Mullein (*Verbascum thapsus*), American Vetch (*Vicia americana*), Prickly Lettuce (*Lactuca serriola*), and Tall Tumble-mustard (*Sisymbrium altissimum*) (Figure 1). These sites were each 2-3 ha in area. The sagebrush sites were natural habitats that have been relatively undisturbed, except for some grazing by feral horses. In addition to sagebrush and rabbit brush, these sites had Bluebunch Wheatgrass, Downy Brome (*Bromus tectorum*), Diffuse Knapweed (*Centaurea diffusa*), Yellow Salsify, and Six-weeks Fescue (*Vulpia octoflora*) (Figure 2). These sites were each 5-6 ha in area. The Ponderosa Pine forest sites were also natural habitats which have had little disturbance, except for grazing by horses. Ponderosa Pine was the major tree species with Bluebunch Wheatgrass, Downy Brome, Balsamroot (*Balsamorhiza sagittata*), and Diffuse Knapweed as the dominant herbs (Figure 3). These sites were each 5-6 ha in area. All study sites were located in the Bunchgrass and Ponderosa pine biogeoclimatic zones (Meidinger and Pojar 1991).

Experimental design

The study had a completely randomized design with three replicate sites of each habitat type. The 9 sites (3 habitat types \times 3 replicates) were selected on the basis of availability of reasonably uniform vegetative characteristics of a given habitat type and proximity to one another. All sites were spatially segregated (0.20 – 0.62 km apart) to enhance statistical independence (Hurlbert 1984).

Population dynamics

Populations of Great Basin Pocket Mice and Western Harvest Mice were sampled at 4-week intervals from April to November 1999, April to October 2000, April to December 2001, and April to August 2002; and for logistical reasons of winter snow cover, at 5- to 8-week intervals from December 2001 to March 2002 and from August 2002 to March 2003. One trapping grid (1 ha), with 49 (7 \times 7) trap stations at 14.3-m intervals, and one Longworth live-trap at each station were located in each site. Traps were supplied with whole oats and carrot, with cotton as bedding. Traps



FIGURE 1. Photograph of the old field habitat at Summerland in the Okanagan Valley, south-central British Columbia, Canada.

were set on the afternoon of day 1, checked on the morning and afternoon of day 2 and morning of day 3, and then locked open between trapping sessions.

All animals captured were ear-tagged with serially numbered tags, breeding condition noted, weighed on Pesola spring balances, and capture coordinates recorded. Breeding condition was noted by the size of testes in males and mammarys (lactation) in females (Krebs et al. 1969). Animals were released on the grids immediately after processing.

Other terrestrial small mammals that occurred in the study area included the Deer Mouse (*Peromyscus maniculatus*), Montane Vole (*Microtus montanus*), Long-tailed Vole (*Microtus longicaudus*), Yellow-pine Chipmunk (*Tamias amoenus*), House Mouse (*Mus musculus*), Wandering Shrew (*Sorex vagrans*), and Short-tailed Weasel (*Mustela erminea*). Seasons were defined as summer (April to September) and winter (October to March) periods. Thus, there were four summer and two winter periods that had at least five trapping sessions.

We used mass at sexual maturity to infer age classes of animals. Body mass was used as an index of age. The percentage of sexually mature animals was used to determine the mass limitations for juveniles and adults assuming that juveniles were seldom, if ever, sexually mature, and that at least 50% of the adults were sexually mature in their lowest mass class. Great

Basin Pocket Mice (juvenile = 1 – 18 g, adult ≥ 19 g) and Western Harvest Mice (juvenile = 1 – 10 g, adult ≥ 11 g) were classified as juvenile or adult by body mass. Recruits were defined as new animals that entered the population through reproduction and immigration. All handling of animals was in accordance with the principles of the Animal Care Committee, University of British Columbia.

Demographic variables

To compare the abundance of these two species in the different habitats, we measured trappability and population density. Jolly trappability was calculated according to the population estimates discussed by Krebs and Boonstra (1984). Population densities were estimated by the Jolly-Seber (J-S) model (Seber 1982) with small sample size corrections (Krebs 1991). Number of animals captured was used as the population estimate for the first and last sampling weeks when the J-S estimate was not calculated. The reliability of the J-S model declines when population sizes are very low and no marked animals are captured (Krebs et al. 1986). For these sample weeks, a minimum number of animals known to be alive (MNA) (Krebs 1966) value was used in place of a J-S estimate.

Measurements of recruitment, number of successful pregnancies, and early juvenile survival were derived



FIGURE 2. Photograph of the sagebrush habitat at Summerland in the Okanagan Valley, south-central British Columbia, Canada.

from the sample of animals captured in each trapping session and then summed for summer periods. Juvenile survival is an index relating recruitment of young into the trappable population to the number of lactating females (Krebs 1966). A modified version of this index is number of juvenile animals at week t divided by the number of lactating females caught in week $t - 4$. Mean survival rates (28-day) for summer and winter periods were estimated from the Jolly-Seber model.

Statistical analysis

A repeated-measures analysis of variance (RM) ANOVA (SPSS version 15.0; SPSS Institute Inc. 2007) was conducted to test for differences among habitats for the demographic variables of mean abundance, mean number of successful pregnancies, mean early juvenile survival, and mean J-S survival for populations of the two species. A univariate ANOVA was conducted on mean number of recruits for each species. A univariate ANOVA was also conducted within each period for significant site \times time interactions in the RM-ANOVAs. Data not conforming to properties of normality and equal variance were subjected to various transformations to best approximate the assumptions required by an ANOVA (Zar 1999). Mauchly's W -test statistic was used to test for sphericity (inde-

pendence of data among repeated measures) (Littel 1989; Kuehl 1994). For datasets that were correlated among years, the Huynh-Feldt (H-F) correction (Huynh and Feldt 1976) was used to adjust the degrees of freedom of the within-subjects F -ratio. Duncan's multiple range test (DMRT) was used to compare mean values. We also calculated mean values for summer and winter periods, as well as for overall mean abundance with 95% confidence intervals (CI) for each species.

In all analyses, the level of significance was $P = 0.05$.

Results

Abundance

A total of 39 trapping periods were conducted from April 1999 to March 2003. The total numbers of individuals captured in the old field, sagebrush, and Ponderosa Pine habitats for Great Basin Pocket Mice were 139, 256, and 103 (total = 498), respectively, and for Western Harvest Mice were 189, 66, and 5 (total = 260), respectively. Estimates of Jolly trappability (susceptibility to capture) tended to be variable for each species, with overall mean values ranging from 50.2% to 61.8% for Great Basin Pocket Mice and 39.6% to 48.6% for Western Harvest Mice.

Population changes for Great Basin Pocket Mice indicated increasing numbers up to a peak density of



FIGURE 3. Photograph of the Ponderosa Pine forest habitat at Summerland in the Okanagan Valley, south-central British Columbia, Canada.

45.5 animals/ha in sagebrush habitats in 1999, with declining abundance in 2001 and 2002 (Figure 4A). Mean density of Great Basin Pocket Mice per ha was similar ($F_{2,6} = 3.48$, $P = 0.10$) among sites, ranging from lows of 12.0–13.7 to highs of 22.2–28.0 (Table 1). The very low numbers recorded in winter 2002–2003 likely reflect hibernation. Population changes of Great Basin Pocket Mice were very similar between the old field and pine forest habitats (Figure 4A). Highest mean overall density per ha consistently occurred in the sage habitat (19.0) compared with the old field (5.0) or pine forest (5.1) habitats (Figure 4B). This pattern occurred in all years except summer 2001 when the sage and pine forest had statistically similar numbers, based on the significant site \times time interaction. The Great Basin Pocket Mouse was not captured during the winter seasons of sampling owing to hibernation.

Western Harvest Mice exhibited seasonal changes in abundance with significantly different mean densities among sites in winter ($F_{2,6} = 5.14$, $P = 0.05$), but not summer ($F_{2,6} = 4.27$, $P = 0.07$) (Table 1, Figure 5A). This mouse occurred primarily in the old field habitats, reaching annual peaks in abundance ranging from 5.3 to 10.5 animals per ha in the fall and early winter months (Figure 5A). This pattern was main-

tained in most seasons except summer 1999 and 2000 when the old field and sage sites had similar (DMRT, $P = 0.05$) densities (Table 1). Mean overall abundance of Western Harvest Mice per ha was highest in the old field (3.7) compared with the sage (0.8) and pine forest (0.05) habitats (Figure 5B).

Reproduction and recruitment

Reproductive performance was measured by the mean number of lactating females and was similar ($F_{2,5} = 3.07$, $P = 0.14$) among sites for Great Basin Pocket Mice (Table 2). The mean number of lactating females of Western Harvest Mice was also similar ($F_{1,4} = 2.32$, $P = 0.20$) among sites, but with 5.2 times, on average, as many females lactating in the old field as in sage habitats. This was a consistent pattern throughout the study. Another measure of reproductive effort was the percentage of adult males in breeding condition over the four summers. This metric was calculated over all captures, and hence provided a degree of difference among habitats for each species. Mean percentages, with sample sizes, of male Great Basin Pocket Mice breeding were 50.9 ($n = 55$), 61.2 ($n = 255$), and 42.9 ($n = 35$) in the old field, sage, and pine forest habitats, respectively. Mean percentages of adult male Western Harvest Mice breeding were 75.0

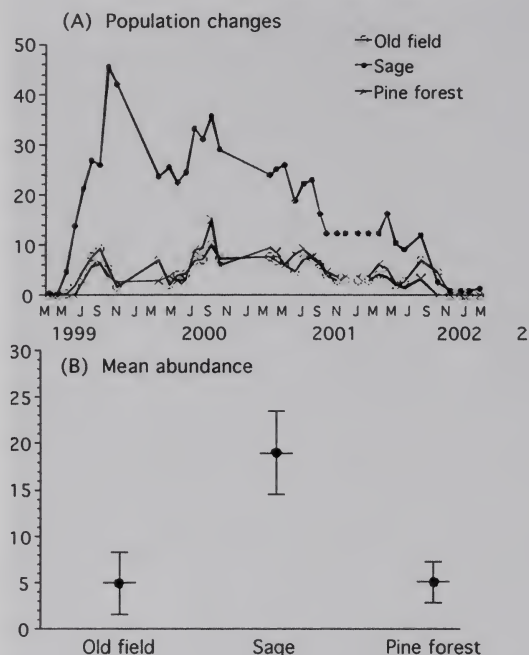
Perognathus parvus

FIGURE 4. (A) Population changes in mean number of animals per ha from 1999 to 2003, and (B) overall mean abundance per ha \pm 95% confidence intervals ($n = 12$; 3 sites \times 4 seasons) for Great Basin Pocket Mice in the three habitats at Summerland, British Columbia, Canada. M=March; M=May; J=July; S=September; N=November; J=January. Hibernation periods from mid-October to late March.

($n = 52$) and 75.0 ($n = 16$) in the old field and sage habitats, respectively.

Recruitment of new Great Basin Pocket Mice and Western Harvest Mice was variable throughout the study and there were no statistically significant ($P > 0.05$) differences for any of the comparisons (Table 3). First captures of Western Harvest Mice were very few in the pine forest, but the 2.9-times higher number of total recruits in the old field (63.0) than sage (22.0) habitats was quite striking (Table 3).

Survival

The mean index of juvenile survival for Great Basin Pocket Mice was similar ($F_{2,5} = 2.49$, $P = 0.18$) among sites (Table 4). The mean total index was comparable in the old field (5.45) and pine forest (5.94), both 2.1–2.3 times higher than the sage habitat (Table 4). This measure of juvenile survival was quite variable for Western Harvest Mice, and hence there were no differences ($F_{1,4} = 0.44$, $P = 0.54$) between the two habitats (Table 4). Mean estimates of Jolly-Seber survival for male and female Great Basin Pocket Mice were

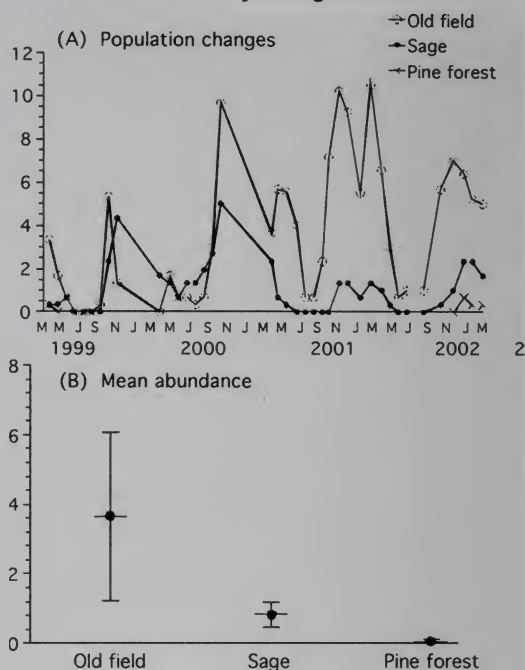
Reithrodontomys megalotis

FIGURE 5. (A) Population changes in mean number of animals per ha from 1999 to 2003, and (B) overall mean abundance per ha \pm 95% confidence intervals ($n = 18$; 3 sites \times 6 seasons) for Western Harvest Mice in the three habitats at Summerland, British Columbia, Canada. M=March; M=May; J=July; S=September; N=November; J=January.

similar among sites during summer and winter periods (Table 5). Mean survival for Western Harvest Mice was variable, but was also similar among sites for both males and females (Table 6).

Discussion

Great Basin Pocket Mouse

This investigation follows that of Iverson (1967) in evaluating the population dynamics of the Great Basin Pocket Mouse in southern British Columbia, at the northern limit of its range. The Great Basin Pocket Mouse was 3.8 times more abundant in sagebrush habitat than in old field or Ponderosa Pine forest, indicating prime habitat for this heteromyid rodent. This finding was similar to reports for this species in other shrub-steppe habitats in western North America (O'Farrell et al. 1975; Verts and Kirkland 1988). Estimates of density per ha for populations of Great Basin Pocket Mice ranged from peaks of 42–82 in south-central Washington (Gray 1943; Hedlund and Rogers 1980). O'Farrell et al. (1975) reported sustained abun-

TABLE 1. Mean \pm SE ($n = 3$ replicate sites) abundance per ha of Great Basin Pocket Mice and Western Harvest Mice during four summer and four winter periods within three different habitats and results of RM-ANOVA. F -values identified by * were calculated using the H-F correction factor, which decreased the stated degrees of freedom due to correlation of data among repeated measures (time periods). Mean values with different letters are significantly different by Duncan's multiple range test (adjusted for multiple contrasts). Within a row, different uppercase letters represent significant site differences as indicated by overall RM-ANOVA. Lowercase letters are used to indicate the location of significant differences resulting from univariate ANOVAs.

Species and period	Site			Overall RM-ANOVA					
	Old field	Sage	Pine forest	Site		Time		Site \times time	
Pocket Mice									
Summer				$F_{2,6}$	P	$F_{3,18}$	P	$F_{6,18}$	P
Averaged over 4 summers	4.97 \pm 1.53	18.98 \pm 2.05	5.09 \pm 1.01	3.48	0.10	9.01	<0.01	0.56	0.76
1999	3.43 \pm 2.50	13.72 \pm 0.84	2.10 \pm 0.13						
2000	5.94 \pm 3.05	28.01 \pm 0.85	6.61 \pm 2.34						
2001	6.59 \pm 4.39	22.17 \pm 2.05	7.95 \pm 1.95						
2002	3.90 \pm 3.60	12.03 \pm 1.73	3.68 \pm 1.59						
Harvest Mice									
Summer				$F_{2,6}$	P	$F_{3,18}$	P	$F_{6,18}$	P
Averaged over 4 summers	1.88 \pm 0.54	0.62 \pm 0.20	0.01 \pm 0.01	4.27	0.07	4.89*	0.02	10.44*	<0.01
1999	0.86 \pm 0.79	0.19 \pm 0.19	0.05 \pm 0.05						
2000	1.00 \pm 1.00	1.56 \pm 0.42	0.00 \pm 0.00						
2001	3.22 ^a \pm 1.54	0.48 ^b \pm 0.27	0.00 ^b \pm 0.00						
2002	2.45 ^a \pm 0.68	0.27 ^b \pm 0.18	0.00 ^b \pm 0.00						
Winter				$F_{2,6}$	P	$F_{3,18}$	P	$F_{6,18}$	P
Averaged over 4 winters	6.85 ^A \pm 2.32	2.70 ^{AB} \pm 0.78	0.07 ^B \pm 0.04	5.14	0.05	1.21*	0.33	2.07*	0.11
1999/2000	3.33 \pm 2.62	3.33 \pm 1.88	0.00 \pm 0.00						
2000/2001	9.67 \pm 7.67	5.00 \pm 2.08	0.00 \pm 0.00						
2001/2002	8.53 \pm 5.11	0.93 \pm 0.13	0.00 \pm 0.00						
2002/2003	5.86 \pm 3.81	1.53 \pm 0.59	0.27 \pm 0.07						

TABLE 2. Mean \pm SE ($n = 3$ replicate sites) number of lactating females for Great Basin Pocket Mice and Western Harvest Mice within three different habitats during four summer periods and results of RM-ANOVA. Mean values with different letters are significantly different by Duncan's multiple range test (adjusted for multiple contrasts). Within a row, different uppercase letters represent significant site differences as indicated by overall RM-ANOVA. Lowercase letters are used to indicate the location of significant differences resulting from univariate ANOVAs.

Species and period	Site			Overall RM-ANOVA					
	Old field ¹	Sage	Pine forest	Site		Time		Site \times time	
Pocket Mice									
Summer				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Averaged over 4 summers	1.88 \pm 0.48	5.92 \pm 0.87	1.92 \pm 0.74	3.07	0.14	2.02	0.15	3.84	0.02
1999	2.50 ^{ab} \pm 1.50	8.33 ^a \pm 0.33	0.67 ^b \pm 0.67						
2000	1.50 ^{ab} \pm 0.50	7.33 ^a \pm 2.19	1.00 ^b \pm 0.58						
2001	2.00 \pm 1.00	4.00 \pm 1.00	4.67 \pm 2.33						
2002	1.50 \pm 1.50	4.00 \pm 1.73	1.33 \pm 0.88						
Harvest Mice									
Summer				$F_{1,4}$	P	$F_{3,12}$	P	$F_{3,12}$	P
Averaged over 4 summers	2.58 \pm 0.93	0.50 \pm 0.19	/	2.32	0.20	6.94	<0.01	3.08	0.07
1999	0.00 \pm 0.00	0.00 \pm 0.00	/						
2000	1.33 \pm 1.33	0.67 \pm 0.33	/						
2001	5.00 \pm 2.65	0.67 \pm 0.67	/						
2002	4.00 \pm 1.53	0.67 \pm 0.33	/						

¹ $n = 2$ for Great Basin Pocket Mice in old field sites.

TABLE 3. Mean \pm SE ($n = 3$ replicate sites) number of first captures for male and female Great Basin Pocket Mice and Western Harvest Mice during the four-year study and results of a univariate ANOVA.

Species	Site			ANOVA	
	Old field ¹	Sage	Pine forest		
Great Basin Pocket Mice					
Males	34.0±18.0	44.3±4.4	17.0±5.9	$F_{2,5}$ 2.92	P 0.14
Females	35.5±26.5	41.7±8.0	17.3±2.7	1.29	0.35
Total	69.5±44.5	86.0±10.8	34.4±8.4	2.03	0.22
Western Harvest Mice					
Males	31.7±15.9	14.7±4.1	0.3±0.3	$F_{2,6}$ 2.73	P 0.14
Females	31.3±19.1	7.3±1.9	1.3±0.9	2.05	0.21
Total	63.0±35.0	22.0±5.8	1.7±0.7	2.32	0.18

¹ $n = 2$ for Great Basin Pocket Mice in old field sites.TABLE 4. Mean \pm SE ($n = 3$ replicate sites) juvenile survival for Great Basin Pocket Mice and Western Harvest Mice within three different habitats during four summer periods and results of RM-ANOVA. F -values identified by * were calculated using the H-F correction factor, which decreased the stated degrees of freedom due to correlation of data among repeated measures (time periods).

Species and period	Site			Overall RM-ANOVA					
	Old field ¹	Sage	Pine forest	Site		Time		Site \times time	
Great Basin Pocket Mice									
Average of 4 summers	4.67 \pm 0.99	3.28 \pm 0.65	1.82 \pm 0.57	$F_{2,5}$ 2.49	P 0.18	$F_{3,15}$ 1.24	P 0.33	$F_{6,15}$ 0.78	P 0.60
1999	5.50 \pm 0.50	2.48 \pm 0.05	0.83 \pm 0.83						
2000	7.50 \pm 0.50	4.06 \pm 2.32	3.50 \pm 1.89						
2001	3.34 \pm 2.34	2.83 \pm 0.34	1.84 \pm 0.64						
2002	2.34 \pm 2.34	3.75 \pm 1.75	1.11 \pm 0.59						
Western Harvest Mice									
Average of 4 summers	1.72 \pm 0.77	1.46 \pm 0.94	/	$F_{1,4}$ 0.44	P 0.54	$F_{3,12}$ 2.83*	P 0.09	$F_{3,12}$ 1.32*	P 0.31
1999	0.00 \pm 0.00	0.00 \pm 0.00	/						
2000	2.08 \pm 2.08	4.67 \pm 3.28	/						
2001	3.87 \pm 2.07	1.17 \pm 1.17	/						
2002	0.93 \pm 0.58	0.00 \pm 0.00	/						

¹ $n = 2$ for Great Basin Pocket Mice in old field sites.

dance of ≥ 80 pocket mice per ha in years of above average precipitation and subsequent high plant productivity. Studies seemed to confirm the positive relationship between autumn precipitation and seed resources (O'Farrell et al. 1975; Dunigan et al. 1980; Hedlund and Rickard 1981). Our populations of Great Basin Pocket Mice reached an average annual high abundance of 45/ha in October 1999 before declining over the next three years. Peak density per ha on one replicate site reached a high of 78 pocket mice during fall 1999, which was within the range of other published accounts. Declining abundance of this species may have been related to lower plant productivity, but we do not have records of relative growth of vegetation or precipitation for the four years of our study.

The sagebrush sites had the highest species richness of herbs and total species diversity of vascular plants (herbs, shrubs, and trees) of the three habitats (Sullivan and Sullivan 2006). Structural diversity (number

of layers of vegetation and relative abundance in each layer) of shrubs was comparable in the sage and pine forest habitats with a negligible shrub layer in the old field habitat (Sullivan and Sullivan 2006). Thus, the cover provided by sagebrush and the richness and diversity of seed-bearing plants likely contributed to the preference for sage habitats by Great Basin Pocket Mice. Shrub cover has been reported to be particularly important for Great Basin Pocket Mice (Feldhamer 1979; Gano and Rickard 1982).

It may be biologically relevant that the sage habitat had consistently higher total and overall mean numbers (3.1 times) of lactating females than either of the old field or pine forest habitats. This pattern was recorded in all years except 2001 and 2002 where this measure of reproductive effort was similar among sites. Thus, the apparent higher productivity of Great Basin Pocket Mice in the sage habitat than other habitats tended to follow the pattern of greater abundance

TABLE 5. Mean \pm SE ($n = 3$ replicate sites) Jolly-Seber 28-day survival for male and female Great Basin Pocket Mice within three different habitats during four summer and four winter periods and results of RM-ANOVA. F -values identified by * were calculated using the H-F correction factor, which decreased the stated degrees of freedom due to correlation of data among repeated measures (time periods).

Period	Site			Overall RM-ANOVA					
	Old field ¹	Sage	Pine forest	Site		Time		Site \times time	
Males									
<i>Summer</i>				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Average of 4 summers	0.71 \pm 0.06	0.82 \pm 0.04	0.80 \pm 0.05	0.47	0.65	0.34*	0.78	1.14*	0.39
1999	0.68 \pm 0.16	0.88 \pm 0.02	0.86 \pm 0.08						
2000	0.68 \pm 0.17	0.88 \pm 0.01	0.80 \pm 0.18						
2001	0.70 \pm 0.17	0.87 \pm 0.04	0.76 \pm 0.11						
2002	0.79 \pm 0.04	0.63 \pm 0.07	0.79 \pm 0.11						
<i>Winter</i>				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Average of 4 winters	0.82 \pm 0.07	0.90 \pm 0.04	0.87 \pm 0.03	3.48	0.11	8.88*	<0.01	1.79*	0.18
1999/2000	0.85 \pm 0.03	0.99 \pm 0.00	0.86 \pm 0.05						
2000/2001	1.00 \pm 0.00	0.98 \pm 0.02	0.96 \pm 0.04						
2001/2002	0.81 \pm 0.08	0.95 \pm 0.01	0.83 \pm 0.03						
2002/2003	0.63 \pm 0.24	0.67 \pm 0.05	0.85 \pm 0.08						
Females									
<i>Summer</i>				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Average of 4 summers	0.84 \pm 0.03	0.82 \pm 0.03	0.84 \pm 0.03	0.2	0.77	0.14	0.94	1.86	0.15
1999	0.84 \pm 0.07	0.87 \pm 0.06	0.74 \pm 0.06						
2000	0.82 \pm 0.04	0.86 \pm 0.03	0.87 \pm 0.09						
2001	0.74 \pm 0.03	0.82 \pm 0.04	0.92 \pm 0.06						
2002	0.95 \pm 0.05	0.73 \pm 0.10	0.82 \pm 0.02						
<i>Winter</i>				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Average of 4 winters	0.81 \pm 0.07	0.85 \pm 0.05	0.85 \pm 0.03	0.12	0.89	28.68	<0.01	2.09	0.12
1999/2000	0.81 \pm 0.19	0.95 \pm 0.00	0.85 \pm 0.03						
2000/2001	0.95 \pm 0.05	0.95 \pm 0.01	0.94 \pm 0.01						
2001/2002	0.88 \pm 0.00	0.93 \pm 0.02	0.88 \pm 0.02						
2002/2003	0.59 \pm 0.20	0.55 \pm 0.04	0.73 \pm 0.04						
Total									
<i>Summer</i>				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Average of 4 summers	0.75 \pm 0.03	0.81 \pm 0.04	0.79 \pm 0.04	0.31	0.75	0.91	0.46	1.30	0.32
1999	0.73 \pm 0.05	0.87 \pm 0.01	0.80 \pm 0.10						
2000	0.75 \pm 0.11	0.87 \pm 0.01	0.79 \pm 0.11						
2001	0.72 \pm 0.08	0.86 \pm 0.01	0.84 \pm 0.07						
2002	0.82 \pm 0.02	0.65 \pm 0.10	0.74 \pm 0.08						
<i>Winter</i>				$F_{2,5}$	P	$F_{3,15}$	P	$F_{6,15}$	P
Average of 4 winters	0.79 \pm 0.08	0.86 \pm 0.05	0.84 \pm 0.04	0.91	0.46	22.97	<0.01	1.31	0.31
1999/2000	0.88 \pm 0.13	0.98 \pm 0.01	0.85 \pm 0.06						
2000/2001	0.98 \pm 0.02	0.96 \pm 0.01	0.95 \pm 0.02						
2001/2002	0.81 \pm 0.11	0.93 \pm 0.02	0.89 \pm 0.05						
2002/2003	0.52 \pm 0.18	0.57 \pm 0.04	0.69 \pm 0.05						

¹ $n = 2$ for old field sites.

of animals in the sage sites. Females tended to have one or two litters (Verts and Kirkland 1988), but two pocket mice appeared to have three litters. One of these individuals lived in the sage and the other individual lived in the pine forest. Iverson (1967) also reported the occurrence of triple litters in Great Basin Pocket Mice. It may also be biologically meaningful that mean total first captures of Great Basin Pocket Mice were 1.2 times higher in the sage than in the old field habitats and this comparison was 2.5 times higher in the sage than in the pine forest habitats. In addition,

total first captures of Great Basin Pocket Mice were 2.0 times higher in the old field than in the pine forest (Table 3).

Western Harvest Mouse

The Western Harvest Mouse is classified as a naturally rare species that occupies grassland and sagebrush habitats (Nagorsen 1995*). Our data support this observation documenting an overall mean abundance per ha 4.6 times higher in old field than sagebrush habitat. Although populations reached only 10 harvest mice per ha in the old field habitat of this study, a Western

TABLE 6. Mean \pm SE ($n = 3$ replicate sites) Jolly-Seber 28-day survival for male and female Western Harvest Mice within three different habitats during four summer and four winter periods and results of RM-ANOVA. F -values identified by * were calculated using the H-F correction factor, which decreased the stated degrees of freedom due to correlation of data among repeated measures (time periods).

Period	Site			Overall RM-ANOVA					
	Old field	Sage	Pine forest	Site		Time		Site \times time	
Male									
<i>Summer</i>									
Average of 4 summers	0.78 \pm 0.05	0.86 \pm 0.04	/	$F_{1,4}$ 0.62	P 0.48	$F_{3,12}$ 4.19*	P 0.08	$F_{3,12}$ 0.85*	P 0.44
1999	0.87 \pm 0.13	0.92 \pm 0.08	/						
2000	0.89 \pm 0.11	0.88 \pm 0.09	/						
2001	0.65 \pm 0.07	0.73 \pm 0.04	/						
2002	0.69 \pm 0.04	0.89 \pm 0.06	/						
<i>Winter</i>									
Average of 4 winters	0.75 \pm 0.04	0.85 \pm 0.04	/	$F_{1,4}$ 2.98	P 0.16	$F_{3,12}$ 1.00*	P 0.42	$F_{3,12}$ 2.76*	P 0.10
1999/2000	0.78 \pm 0.13	0.88 \pm 0.07	/						
2000/2001	0.81 \pm 0.04	0.70 \pm 0.06	/						
2001/2002	0.71 \pm 0.07	0.83 \pm 0.09	/						
2002/2003	0.68 \pm 0.07	0.97 \pm 0.03	/						
Female									
<i>Summer</i>									
Average of 4 summers	0.77 \pm 0.06	0.93 \pm 0.03	/	$F_{1,4}$ 2.65	P 0.18	$F_{3,12}$ 3.85	P 0.04	$F_{3,12}$ 2.92	P 0.08
1999	0.92 \pm 0.08	1.00 \pm 0.00	/						
2000	0.89 \pm 0.11	0.87 \pm 0.06	/						
2001	0.63 \pm 0.09	0.88 \pm 0.12	/						
2002	0.64 \pm 0.12	0.96 \pm 0.04	/						
<i>Winter</i>									
Average of 4 winters	0.79 \pm 0.05	0.88 \pm 0.03	/	$F_{1,4}$ 1.83	P 0.25	$F_{3,12}$ 0.03*	P 0.99	$F_{3,12}$ 1.61*	P 0.25
1999/2000	0.84 \pm 0.16	0.80 \pm 0.10	/						
2000/2001	0.83 \pm 0.04	0.85 \pm 0.08	/						
2001/2002	0.79 \pm 0.09	0.88 \pm 0.04	/						
2002/2003	0.69 \pm 0.06	0.97 \pm 0.03	/						
Total									
<i>Summer</i>									
Average of 4 summers	0.71 \pm 0.07	0.82 \pm 0.05	/	$F_{1,4}$ 0.81	P 0.42	$F_{3,12}$ 4.07*	P 0.04	$F_{3,12}$ 1.32*	P 0.32
1999	0.85 \pm 0.15	0.92 \pm 0.08	/						
2000	0.85 \pm 0.15	0.82 \pm 0.11	/						
2001	0.58 \pm 0.07	0.68 \pm 0.08	/						
2002	0.54 \pm 0.05	0.85 \pm 0.07	/						
<i>Winter</i>									
Average of 4 winters	0.72 \pm 0.05	0.81 \pm 0.04	/	$F_{1,4}$ 1.81	P 0.25	$F_{3,12}$ 0.22*	P 0.86	$F_{3,12}$ 1.81*	P 0.21
1999/2000	0.73 \pm 0.18	0.83 \pm 0.09	/						
2000/2001	0.80 \pm 0.02	0.68 \pm 0.06	/						
2001/2002	0.72 \pm 0.10	0.78 \pm 0.10	/						
2002/2003	0.62 \pm 0.08	0.95 \pm 0.03	/						

Harvest Mouse density peaked at 80 animals/ha in December in an irrigated old field with residual Alfalfa plants (Sullivan and Sullivan 2004). The mean (\pm SE) number of individuals per ha for that year were 29.2 ± 23.5 with other densities ≤ 10 animals/ha in less productive old field habitats (Sullivan and Sullivan 2004). Other habitats occupied by Western Harvest Mice in the Okanagan Valley included an unmanaged apple orchard where in one winter 10 harvest mice/ha were captured, and one animal/ha periodically occurring in managed apple orchards, hedgerows, and riparian habitats (Sullivan and Sullivan 2006).

The variable numbers of Western Harvest Mice, with peak density (up to 13/ha) in winter and very low densities in summer, were also reported by Skupski

(1995) in Arizona. Brady and Slade (2004) reported densities of Western Harvest Mice in old field habitat in Kansas ranging from 0 to about 27/ha. Similarly, in Kansas, Johnson and Gaines (1988) observed seasonal fluctuation in population densities, but with relatively constant numbers over several years. Blaustein (1981) reported that population densities of Western Harvest Mice fluctuated from 0 to 60/ha and 0 to 90/ha in disturbed grassland communities in California. Heske et al. (1984) also found periodic extirpations of harvest mice in California meadows with densities as high as 20/ha.

Our reproductive analysis of Western Harvest Mice supported the abundance pattern with more lactating females and recruits occurring in the old field than in

sagebrush habitats. Not surprisingly, the Western Harvest Mouse has been reported to have variable patterns of reproductive activity consistent with variable densities of mice through time in a given habitat (Brown and Zeng 1989; Skupski 1995). Lactating females were recorded in spring (March to May) and autumn (October–November) in the four years of this study.

The variable pattern of population dynamics of Western Harvest Mice in certain habitats may fit a source-sink dynamics pattern (Pulliam 1988; Skupski 1995). Thus, this rodent species may be able to persist among the “good” and “poor” habitats of a fragmented landscape. This potential is enhanced by its apparent dispersal ability (Whitaker and Mumford 1972; Ford 1977) and relatively high rates of recruitment in prime habitats (Sullivan and Sullivan 2004). Another possible explanation for the variable densities of Western Harvest Mice was competition with other small mammals, particularly *Microtus* spp. Abundance of Western Harvest Mice did seem less when there was high (>20/ha) numbers of montane voles in this study (Sullivan and Sullivan, unpublished) and in terms of interspecific competition (Heske et al. 1984; Johnson and Gaines 1988; Sullivan and Sullivan 2004).

Conclusions

Peripheral populations of Great Basin Pocket Mice and Western Harvest Mice in southern British Columbia had similar patterns of abundance to those reported in published accounts from other parts of their respective ranges. This conclusion suggested that the “abundant-center model” (Sagarin and Gaines 2002; Guo et al. 2005), whereby peripheral populations are less demographically viable than their counterparts closer to the geographic centre of their ranges, may not hold for these particular rodent species. Clearly, a concurrent evaluation of population dynamics of these species across their ranges would provide a rigorous test of this hypothesis.

The preference for sagebrush habitats by Great Basin Pocket Mice and its apparently poor dispersal ability, suggests that such sites, including old fields, need to be conserved as non-linear components within a mosaic of natural and anthropogenic habitats. Western Harvest Mice, on the other hand, may do well in linear and non-linear habitats with a high biomass and structural diversity of grasses and forbs. Various configurations of linear habitats in the form of hedgerows, field edges, fence lines, roadsides, and ditches may provide sufficient habitat for the Western Harvest Mouse if the vegetative component is maintained. To this end, linear habitats created within and bordering on the fields of agricultural crops (e.g., tree fruits and vineyards) could help curb the eroding habitat base for these species.

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Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars a AUD and so on.

ZOOLOGY

Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding, Sixth Edition

Edited by Brian I. Crother. 2008. Society for the Study of Amphibians and Reptiles Herpetological Circular 37. 84 pages. USD 12.00.

This slender volume resets the standard for scientific and English ["common"] names to current usage for all amphibians and reptiles recorded for North America (Canada and the United States) and is the official list for all three major herpetological societies based in the United States (The Society for the Study of Amphibians and Reptiles, The American Society of Ichthyologists and Herpetologists, The Herpetologists League). It is the product of a committee of prominent herpetologists consisting of Crother (chair), Jeff Boundy, Frank T. Burbrink, Jonathan A. Campbell, Kevin de Queiroz, Darrel R. Frost, Richard Highton, John B. Iverson, Fred Krus, Roy W. McDiarmid, Joseph R. Mendelson III, Peter A. Meylan, Tod W. Reeder, Michael E. Seidel, Stephen G. Tilley, and David W. Wake. This sixth edition is the second for which this committee has been responsible. The first was in 2001 (SSAR Herpetological Circular 29) and is now available on the web (<http://www.ssarherps.org/pdf/Crother.pdf>). It was reviewed, together with some historical background on the evolution of the list, in *The Canadian Field-Naturalist* 116(4): 656-658 (2002).

After a one-page introduction and acknowledgments, the text is divided into sections: Anura – frogs: Frost (chair), McDiarmid, Mendelson; Caudata – salamanders: Tilley (chair), Highton, Wake); Squamata – lizards: de Queiroz (chair), Reeder; Squamata – snakes: Crother (chair), Boundy, Burbrink, Campbell; Crocodilia – crocodilians (Crother); Testudines. Turtles: Iverson (chair), Meylan, Seidel.

There are some major changes from the previous edition that affect the scientific names of many Canadian species. The majority of these involve the long-overdue breakups of large genera distributed over more than one continent into groups of their most closely related species. This had been long-delayed because previous piecemeal changes of small segments were not generally adopted due to the lack of an overall revision. This was finally overcome by the publication of a comprehensive synthesis for world amphibians by

Frost et al. in 2006 (Bulletin of the American Museum of Natural History 297).

For toads (*Bufo*) and typical frogs (*Rana*) this has meant major shifts to unfamiliar genera. All strictly North American toads now are designated *Anaxyrus*, including the five (or four, depending on what species concept you follow) Canadian species. All the *Rana* except a few western species become *Lithobates*. This necessitates changes in the termination of some species names to agree in gender with this genus (*Lithobates catesbeianus*, *Lithobates sylvaticus*). The western species which occur in Canada that are retained in *Rana* are *R. aurora*, *R. pretiosa*, and *R. luteiventris*, because they are more closely related to the Eurasian species in this genus than to other North American frogs. Two genera are recognized for spadefoots with the two species reaching Canada both placed in *Spea*.

Other generic changes accepted which affect the names for species which occur in Canada include *Plestiodon* for skinks formerly included in *Eumeces*, and *Pantherophis* for the North American Ratsnakes, formerly included with the Eurasian *Elaphe*. However, not included are changes in a later study which combined the Ratsnakes with the Bullsnares and Gopher Snakes in the genus *Pituophis*; or another study that retains the latter genus in its traditional sense and erects separate genera for the Ratsnakes and the Fox Snakes. In turtles the breakup of the genus *Clemmys* leaves it with only *guttata* while the Western Pond Turtle is placed in the genus *Actinemys* and the Wood Turtle in the genus *Glyptemys*. The genus *Opheodrys* is retained for the Smooth Green Snake rather than following a proposed change to *Liochlorophis*.

On the species level, two species of *Ascaphus* (tailed toads) are recognized and the western populations of the Tiger Salamander are elevated to species status as *Ambystoma mavortium*, but the later move is still controversial. In the rattlesnake genus *Crotalus*, the pacific and the prairie forms are regarded as species, *C. oreganus* and *C. viridis*. The species *Hypsigena torquata* has now been restricted to Mexico, so the form ranging into British Columbia, the Desert Nightsnake, is now *Hypsigena chlorophaea deserticola*.

The book concludes with a section by Klaus on alien (introduced by humans) species: 6 anurans, 54 lizards, 4 snakes, 1 crocodilian, and 2 turtles, the majority of these established in Florida or Hawaii. Of all these newcomers to North America, only one is in Canada, a European lizard on Vancouver Island. Checklists can only reflect the state of knowledge up to press time and how rapidly they become outdated is a direct reflection of how active and innovative current research is in the field they cover. Taxonomy and phylogenetics

in herpetology have enjoyed explosive growth in recent decades and will continue for the near future at least. This checklist cannot be the last word in species status and relationships, but is an essential authoritative benchmark for naturalists' and conservationists' reference now.

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Arctic Fox: Life at the Top of the World

By Garry Hamilton. 2008. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 231 pages. 39.95 USD.

Garry Hamilton has produced a wonderfully written account of a whimsical predator that's not as well researched as some of the more charismatic canid species. He has gone to the source to obtain the most accurate and reliable information: the biologists and graduate students that ventured to the circumpolar region and studied the fox first hand. These interviews and summations of their research provide an added edge that is lacking in today's natural history writing.

The book is divided into three parts: Origins, Adaptations, and Change, with each part containing several chapters. Each chapter covers a particular aspect of Arctic fox biology and is accompanied by outstanding full-color photos by photographer Norbert Rosing. Hamilton uses the stories told by researchers to make various points about the amazing ecology of the Arctic fox and incorporates the journal writings of fox hunters, explorers, and early naturalists that lived within the Arctic fox's realm. With these stories and writings, Hamilton paints a picture of a fox that is a master of conserving energy, is a clever hoarder of goose eggs, and is bold enough to follow polar bears (*Ursus maritimus*) to take advantage of the seal carcasses left behind. Indeed, the most striking aspect of Hamilton's writing is his ability to communicate the adaptability of the little fox, from reproduction to the constant struggle in obtaining food.

When I first saw the book, I assumed it was some sort of coffee table tome – it measures 28 × 22 × 2 cm and is not something easily carried around. However, once I began reading, I soon realized that it was a very well researched book that contains nearly everything currently known about the fox. In short, it is a thorough species account of the Arctic fox, and exceeded my initial expectations.

I was most interested in finding out exactly where the Arctic fox came from. Chapter 3 delves into this question, explaining that it is a result of rapid evolution 200 000 to 400 000 years ago from the swift fox (*Vulpes velox*), which occurs in the Great Plains of the United States stretching from Texas to Canada. Hamil-

ton explains the evolutionary mechanisms and the pressures of natural selection with ease, providing a classic example of adaptation and survival.

The final chapters provide a cautionary statement regarding Arctic fox conservation. One would think that a fox as adaptable as the Arctic fox would not be in jeopardy. But this is not necessarily true. Global climate change is likely to thrust the fox into a state of peril. But other landscape-level challenges are becoming more of an issue. The northern expansion of the red fox (*Vulpes vulpes*) may be driving some populations of Arctic foxes to extinction, especially those in northern Europe. Hamilton explores these inter-specific interactions as well as the lemming cycles and other variables that continue to keep the Arctic fox in survivor mode.

There was only one major error in this book—the use of the Latin name *Alopex lagopus* for the Arctic fox. Whether this is a remnant of past research or the inability to change the name because of publication schedules, it is an unfortunate oversight in a work that is so rich with detail. The 3rd edition of *Mammal Species of the World: A Taxonomic and Geographic Reference* (Wozencraft 2005) places the Arctic fox with the rest of the vulpine foxes, *Vulpes lagopus*. This is mainly due to recent genetic work that proves a close relationship with the swift fox, as mentioned above.

Hamilton's book is a must for those interested in carnivore ecology, and seeking a volume detailing the Arctic fox's struggle within the brutal frozen habitat north of the Arctic Circle. Hamilton states, "...we have come to praise and not to bury our most worthy emperor of the north. Its days are far from done. Indeed, there is only one way in which we could possibly view this most remarkable of creatures – as shining examples of life's ability to survive" [page 216].

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Wozencraft, W. C. 2005. Order Carnivora. Pages 532–628 in *Mammal species of the world: a taxonomic and geographic reference* Edited by D. E. Wilson and D. M. Reeder. 3rd edition. Johns Hopkins University Press, Baltimore, Maryland.

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The Inner Bird – Anatomy and Evolution

By G. W. Kaiser. 2007. UBC Press, University of British Columbia, 2029 West Mall, Vancouver, British Columbia V6T 1Z2 Canada. 386 pages. 85 CAD. Cloth.

Although not as richly illustrated as Feduccia's 1999 book on bird evolution, Kaiser's book is an up-to-date summary of the evolution of birds, including both sides of some of the debates in the field. As its title suggests, the book has little to do with plumage. Only one chapter discusses feathers at any length, presumably because plumage has contributed little (though ever-increasing amounts) to our understanding of bird evolution, relative to the bones, and now the use of DNA. It is the bones that dominate the other chapters, with only passing discussions of soft tissue systems like gas exchange, muscle and digestive.

The book is well organized from basic skeletal anatomy through the dinosaur-bird integrate, to adaptations of birds which allow them to exploit different environments. The chapters of the first section, *What is a Bird*, provide a good anatomical background to the understanding of the future chapters on avian evolution, as largely interpreted by the bones of the fossil record. The author also draws parallels between the extant and the extinct, helping to infer how the latter lived. There is plenty of space devoted to comparing and contrasting birds with dinosaurs.

The frequent references to the primary literature (and a correspondingly large list of references), suggests a thoroughly-researched work. Having said that, there are more than a few (but not a lot of) factual errors. For example, the author claims that feathers are not evolutionarily derived from scales, but hair is; in reality, the reverse is largely considered to be true. Semicircular canals, despite being part of the ears, have nothing to do with hearing, as the author suggests. Double-headed ribs are not unique to birds and dinosaurs, they are widely distributed among the tetrapods. Most of the errors I found were anatomical — it's not clear to me if the cause of this is that the author is a seabird biologist who does not specialize in anatomy, or the reviewer is a specialist in anatomy, and therefore wasn't finding errors in other components of the book which lay outside his specialty.

Seabirds: A Natural History

By A. Gaston. 2004. Yale University Press, [Christopher Helm], P.O. Box 209040, New Haven, Connecticut USA. 210 pages. 45 USD.

Canadians should notice the publication of this book: Since seabirds tend to be good indicators of the ocean environment, they represent how the three Canadian oceans are dealt with. The author, a leading employee

This book fills several gaps in recent ornithological literature. Ornithology textbooks of today, unlike the not-so-distant past, do not spend much space on skeletal anatomy, and when they do, the accounts are largely restricted to the chicken as the typical example. So much of the wonderful variation of avian osteology is described in Kaiser's book, that all researchers could be inspired here. However, it would take a multivolume series to fully explore this field. There are several places in this book where another diagram or two would really help the reader understand the structures being described in the text.

The second section, *What kind of bird is it?*, does as much, as any review book can, to survey the complex evolution of birds from dinosaurs, and the subsequent radiation into their more restrictive clades. Convergence is always a problem to deal with, and has been addressed. Several cladograms are presented, some based on physical characteristics, some, as is the trend, based on DNA. Additionally, there is a lot of discussion of other taxonomic research whose cladograms are not re-illustrated in this book. Given the amount of space allotted to avian evolution, the author has managed to cover the breadth of the topic quite well.

The third section of the book, *How does a bird fly?* takes us from a chapter on feathers and feathered dinosaurs (the shortest chapter in the book) through to adaptations that allow birds to exploit terrestrial and aquatic habitats (with a look at both aerial surface-foragers and diving marine birds). It presents unresolved conundrums such as why loons and grebes fly at considerable height over water, whereas murrelets and cormorants (among others), fly just over the water's surface. These conundrums help to create a book of intrigue, not just one of facts.

Birders will be fascinated with this book as it is written in a language that they will be able to appreciate; ornithologists will find enough detail to satisfy and stimulate them as well.

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Feduccia, Alan. 1999. The origin and evolution of birds. Yale University Press, P.O. Box 209040, New Haven, Connecticut. 480 pages.

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with the Canadian Wildlife Service (CWS) of Environment Canada, presents us with his life's work summary of what seabirds are like, and how they fit into the world. It makes for a challenging book on a complex topic.

The text of 222 pages makes usually for a rather delightful naturalist reading, but it falls short on most relevant conservation management issues citizens are

concerned about. This has been the profile of the Canadian government for decades, and it is nothing a Canadian can be really proud of, or be happy with.

The author has tried to provide us here with a "Naturalist view" on seabirds. Not taking on responsibility that comes with scientific knowledge and being in a high-ranking governmental research position, he tries kindly to retreat into telling "amazing stories" about seabirds (relevant statistical analyses are virtually lacking) and to promote the idea of an "objective" expert science (one that is mostly funded by taxpayers). It blurs the lines because the entire lack of any reference to by-catch, overfishing, (chronic) oil and plastic pollution, and even climate change (topics known for over four decades and globally discussed these days) shows us how wrong this concept from the 1960s has drifted by now: in the wider view of things, such a profile basically makes for a subsidy destroying Canada's oceans (and its seabirds) even further (e.g., Bandura 2007). Evidence comes from the well-knowing author who states that large seabird populations must have existed prior to contact with the (western) human race. He also gives a faint hint that the wrongly assigned and outdated mandates of CWS (looking after seabirds) and the Department of Fisheries and Oceans (Canada) (DFO; looking after fish and the oceans overall) need an urgent revision towards a more meaningful and sustainable concept.

In the elaborate 10 chapters, Gaston presents his assembled expertise, covering "the gamut of seabirds" with topics as diverse as Seabird Types, Adaptation, Plumage, Distributions and Communities, Feeding Behaviour, Migration and Movement, Breeding, Coloniality and Its Consequences, Birth and Death Theory & Observations. An Afterword, a Bibliography and an 11 page Index conclude this compact little book on seabirds of the world with 50 figures and 13 tables. The publication is rather nicely illustrated with photos, colour plates and drawings in black/white by D. Powell, J. Chardine, T. Lash, the author's wife and others.

"Thick-billed Murres may not be the wisest birds in the world" so why study them for your life, and put entire government budgets behind them at the cost of other (more important) things? Gaston never really justifies this question crucial to Canada, but promotes marine ornithology being an interdisciplinary science. He criticizes, correctly, that "seabirds never received much attention from marine biologists." His book is "Looking at seabirds on a global scale" (although Gaston seems to lack relevant seabird experience in the Antarctic, Russia and the pelagic ocean).

The taxonomy presented in this publication shows no source, and comes from the early 1990s. But as a seabird biologist, biological oceanographer, birder and naturalist, you still want to read this book. This is because it is strong on the brainstorming and intellectual side; e.g., density-dependence vs food shortage, and life history questions. Gaston stuns us with conclusions like Emperor Penguins, albatrosses and large petrels would

be more similar in their demographics than pre-agricultural humans. He cites Sindbad the Sailor, and some rather funny text sections are found. The sea is a good place to survive, but a poor one to reproduce (because eggs do not float). Perhaps that's why "Compared with terrestrial birds, there are relatively few species of seabirds"? This publication shows that seabird diversity is higher in the southern hemisphere: the highest number of breeding species occurs on the Crozet archipelago.

Classic seabird concepts carried over from the good old British seabird science days in Oxford and from others (e.g., Murphy, Wynne-Edwards, Lockley, Lack, Nelson, Nice, Cairns) can be found throughout the chapters, e.g., Ashmole's Halo, Hungry Horde and Information Theory where to find food (widely dismissed in animal behavior textbooks though). Readers will learn in some rather fascinating text sections whether birds walk or hop, whether there is territoriality at sea, what the effects are of buoyancy in diving seabirds, how Kleptoparasitism evolved, what chick obesity is, "What is a Colony", whether eye size is a limiting factor in underwater feeding, why seabirds are not smaller, why the U.S. Navy picked colors for their warships matching the plumage of the Antarctic Prion, that most seabirds have a long neck (but a small hindtoe and short tail), whether they can smell, whether "reciprocal altruism" exists in seabirds, how white wing tips and related feather pigments attract flocks, that seabirds can drink saltwater, have feathers for isolation, why they have beak and face ornaments in burrow-nesting seabirds, how foraging range is related to life history, the impact of aspect-ratio for wing loading, that auklets have one of the most unusual songs and that Wandering Albatross take 20 years to develop a mature plumage. Gaston makes a good point that there has been no relevant progress in bird navigation studies for virtually 100 years.

I further liked his hypothesis that the presence of Bald Eagles precludes the existence of Common Murres in the Northwest Pacific, that colony locations existed for thousands of years affecting colour morphs (e.g., in fulmars), and that sharks would generally limit predatory behavior in the tropics. Other fascinating questions deal with diving behavior, why are there no tubenoses in Indonesia, whether seabirds would be "among the most weather-dependent of birds", are chicks at smaller colonies better fed, and do "leks" occur in seabirds; e.g., for Razorbills on boulders? Interesting for biogeographers is the section on "Convergence and Co-Evolution" analysing three boundary upwelling zones (California, Humboldt and Benguela Currents) and their avian communities and endemics.

Gaston's writings on colony-related questions, are obviously strong, specifically for Thick-billed Murres and Ancient Murrelets (basically his life-long pursuits). The spectacular breeding displays of seabirds are not "overly" covered. But readers will appreciate the review of seabird wrecks and irruptions, and find the provid-

ed overview tables and maps very useful (e.g. islands where the world's endemic seabirds are found).

Seabird dispersal and migration is covered in informative detail (e.g., for phalaropes, jaegers, Bonaparte's and Sabine's gulls). Regarding telemetry (a big topic in seabird research these days), resource selection and biomass/prey models, this book is a disappointment. Also no work is presented that involves Geographic Information Systems (GIS) or online mapping initiatives. The book presents monogamy and seabird mating systems, but lacks the exciting findings on Extra-pair Copulations (EPCs), as well as on Stable Isotopes (e.g., Canadian flagship work by K. Hobson) and on the Wilson's Storm Petrel (probably the most abundant bird in the world). The author is also plain wrong in his statement that our ability to predict hot-spots for seabirds would be poor (accuracies of over 80% are reported in the literature). But he is absolutely right that many pelagic seabird colony, survey and distribution data are still unpublished and not publicly available, blocking progress on the world's seabird research and management (examples are found for the Arctic, Antarctic, Indian Ocean, with BirdLife International and many of the surveys involving funding from the U.S. National Science Foundation, ICES and PICES for instance).

Being a naturalist and a modern scientist can mix, beyond log-transformed linear regressions. And so, it's too bad that the demography chapter ends with literature of the late 1980s (whereas a real explosion has happened in this discipline in the last two decades making for a main scheme in colony-based seabird research and management). One should always be doubtful when facts in biology get presented as "it makes sense that" (as done in this book).

Another serious omission is that Gaston does not make reference to another major reference on seabirds by Schreiber and Burger (2002), nor to the extensive works by Nettleship or Montevecchi (or the classic papers on smell by Newell). Since the author is being an international editor for seabird journals, one won-

ders why that is? Citation biases are definitely not professional. The tragedy here is for Canada and its seabirds that the Gaston style equals more or less the CWS style (instead of for instance, Anderson et al. 2003).

Compared to other disciplines, it is striking that so little real progress has been made on seabirds and their habitats and management ("Seabird ecology does not provide many Eureka! moments"), when considering the chronic oil-spill situation in our oceans, overfishing in Newfoundland and elsewhere, and that 17 out of the 19 albatross species are basically of major conservation concern (two species occur in Canadian waters). Considering the impacts of climate change, the times for story telling and of a science that "objectively" gets removed from adaptive management is probably over, certainly for seabirds in the Arctic (a topic Gaston is an expert in) and where we are facing a warming of 8 degrees Celsius.

Overall, we are left here with a nice Gaston-style publication and his views as a self-defined CWS naturalist, but naturalists of this world do cover much more ground and are usually rather concerned about sustainability. A more serious book about seabirds and their habitat, management and conservation — beyond just interesting stories and facts — still awaits to be written so that Canada can be proud again of its traditionally well-balanced values, (governmental) research and an ocean science that truly achieves, long-term.

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BOTANY

Monograph on Bamboo in China

By Yi Tongpei, Shi Junyi, Ma Lisha, Wang Haitao and Yang Lin. Science Press, Beijing, China. 2008. 766 pages, 480.00 CNY Cloth.

In phytotaxonomy, bamboo are monocotyledon woody perennial evergreens (except for some temperate species) plants in the family Gramineae (or Poaceae), subfamily Bambusoideae, tribe Bambuseae. According to the statistics, worldwide totalling more than 70 genera and 1200 species of bamboo covers a total area of about 22 million hm². Bamboo is distributed between the Tropic of Capricorn and the Tropic of Cancer, covering the tropical, subtropical and warm

temperate areas. China, especially the southern part of China, is located in the central distribution area of bamboo. Bamboo in China has 39 genera and 509 species, which is 36% and 39% of the total number of genera and species of bamboo in the world, respectively. Bamboo area in China is about five million hm², which is 4% of the total area of forest in China, and 25% of the total bamboo area in the world.

Early in the period of Yangshao and Hemudu Cultures, about 6000-7000 years ago, the Chinese began to use bamboo in their daily lives and production activities. In China, bamboo has been extensively used in

many aspects, such as source material for clothing, food, housing and transportation. Before the invention of paper-making technique in the ninth century, many important Chinese ancient books, such as the books of Confucius, were all written on bamboo slips. In a sense, bamboo has become a carrier of Chinese civilization. It might be said that if the discovery and use of corn created the splendid Indian culture and history, the use of bamboo created the prosperous civilization and history of China.

In traditional Chinese culture, the straight lines, nodes, hardness and hollow structure of bamboo symbolize the resilience, integrity, unselfishness, resoluteness, honorability, chastity, tenacity, mettle, longevity, condescension, abstention, truth, happiness and so on. Besides being a symbol of virtue, bamboo is endowed with soul and emotion. Chinese not only like the practical uses, but also the spirit of bamboo. Bamboo is sometimes regarded as an indispensable part of daily life by Chinese; this was expressed in the poem of a famous Chinese poet Su Shi in the Song Dynasty, that "I prefer to eat a meal without meat, not to have a home without bamboo." Bamboo is rich in cultural connotations and has influenced and promoted the formation of the sense of aesthetics and ethics of Chinese people, as well as the development of Chinese literature, painting, arts and crafts, garden art, religious culture, folk-custom and music culture (bamboo is an important material for making musical instruments in China). Because bamboo possesses uniquely beautiful and elegant stance as well as the abundant spiritual symbolization, from ancient times, bamboo as a important garden plant has been using widely in landscape design in China. Bamboo, pine and plum are regarded as three best friends or auspicious plants in winter. Additionally including chrysanthemum, they are called the four gentlemen of plant kingdom.

Although the bamboo resource is abundant and the history of use of bamboo is long enough in China, a comprehensive book dealing with Chinese bamboo resource has been rare. The book *Monograph on Bamboo in China* written by Yi et al., comprehensively re-

flected the latest research results on bamboo resource in China.

The book contains large numbers of Chinese species and a small number of introduced bamboo species, totalling 43 genera, 707 species, 52 varieties and 98 variants in Bambusoideae, among which there are more than 1910 pieces of color photos attached to 440 species, 36 varieties, 68 variants and 4 hybrids. Some of these photos were taken in many botanical gardens and bamboo gardens in China, and most of the others were taken in the natural sites where the model specimens originally grew. The morphological characteristics, origin, habitat and elevation of distribution of each species are described in detail. Abundant first-hand information is included in the book. Many data in the book were published for the first time, for example, the photos of more than 300 bamboo species (including the varieties and variants) in their original sites, and the photos of some single-species genera of bamboo. In the book, an elaborate identification key containing all bamboo species in 34 genera except for the species in the single-species genera and there is a map of the distribution of cold-resistant bamboo species. Furthermore, the book collected and listed almost all the original literature published about the newly found bamboo species after around 1996.

The book is well structured, and with few errors. The book has a strong scientific and practical values. Its publication will promote the research, exploitation, protection and management of the bamboo resource in China. This book can serve as a reference for persons who engage in phytotaxonomy, agriculture, forestry or other related fields, or the persons who are interested in bamboo.

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ENVIRONMENT

Tree of Rivers: The Story of the Amazon

By J. Hemming. 2008. Thames & Hudson Inc., 500 Fifth Avenue, New York, New York 10110 USA. 368 pages. 39.95 USD.

The environmental history of the Amazon has a new amazing book, and any naturalist interested in natural world heritages really wants to read it: it represents environmental history *par excellence*.

Most people don't appreciate that the Amazon River provides the cradle for our current western world's industrialization, and that we owe it. Holland's Golden Age, for instance was caused, in part, by sugar from

Brazil. Portugal's period of great wealth 1750s onwards was due to the inflow of gold discovered in Brazil (Minhas Gerais). And 1850 started "the world's greatest boom based on a living plant product", rubber (*Hevea brasiliensis*) and Castilla trees. It was exploited and its use intensified by T. Hancock (father of the international rubber industry), Dunlop, MacIntosh, Firestone, Goodyear (famous for inventing vulcanization), Michelin (France) and Ford (also known for its rubber plantations). A reference to a similar situation in Congo and the Belgium king is made, too. Further,

Amazonia was exploited early on for "drogas de seriao" (drugs of the wild: curupa powder, cacao, coffee, sugar and butter oil from turtle eggs; petroleum was not yet available).

The author selected 70 illustrations and 20 beautiful photos for this impressive book. Thematic maps allow for an overview. Definite strengths of this book are the details on early Portuguese and Spanish explorations. Sources from great chroniclers (e.g. G. de Carvajal) make for nicely rounded presentations. The 11 chapters of this publication show that beyond Portugal and Spain, many countries took part in the early exploration of Amazonia and making their claims; e.g., England, France, Germany, Russia, Austria, Belgium and the United States (this situation reminds us of Antarctica today). Exploring this vast area was only possible due to native paddlers doing all the work. The indigenous populations lived very successfully in the region for thousands of years and they had wealth without a relevant government! Tribes such as the Yanomami, Omagua, Mura, Mundurukuru, Nambiquara, Karaja and Canari are well covered (speaking languages such as Arwak, Carib and Tupi, as the Amazonian *lingua blanca*). The sophisticated *roca* farming and native pottery are elaborated on. The pacification process of the infamous Parintintin tribe is explained, and it is striking to learn that once tribes got contacted and made peace with, e.g. by the Brazilian government or anthropologists, they usually died out quickly (often due to diseases).

The Amazon represents a botanical wonder trough, and famous botanists such as R. Spruce (the greatest botanist of his century and who made the first western experience with cocaine, caapi, yopo and anaesthetics), A.R. Ferreira (whose collection in the Lisbon museum was later re-located to Paris, thanks to Napoleon), H. W. Bates and A. R. Wallace are given much attention. C. Waterton got described as the first environmentalist for Amazonia. With Amazonia being also the world's biggest freshwater fish reservoir, it makes for "the largest river in the largest forest". It becomes clear that the Amazonia region matters globally because of Greenhouse Gases, Loss of Biodiversity and Global Warming (the term Ecological Services is not mentioned by the author though). The Amazon river has uncountable "Wagnerian waterfalls", but its lower 2200 km are sailable right into Peru and make for an international waterway (a legal situation set up through political pressures by the U.S. and Britain). The eastern Andean slopes carry the world's richest biodiversity, and the Amazon basin represents nothing but the world's largest canopy cover, having 427 mammal species (but lacking large mammals like in Africa). Hemming explains that 90% of the animal biomass is actually from insects (the entomology section of this book covers only 1.5 pages though). We learn from the author that termites play a major role in the climate change discussion due to their methane release. For

Amazonia, 30 000 tree species are estimated, and 300 species per hectare can occur (A. Gentry's botany work remains unfortunately unmentioned). The highest known concentration of hallogenic plants is located in the upper Amazonia (Sibundoy); related work by R. Evans Schulte from Harvard (the father of ethnobotany; a concept now widely exploited by pharmaceutical companies) is discussed.

Often overlooked elsewhere, the 368 pages of this book nicely emphasize relevant historical treaties (Tordesillas, Madrid, San Ildefonso, Peace of Paris, and Petropolis). Further, we learn that "Napoleon's invasion of Spain and Portugal had a profound impact in South America", e.g. the Portuguese Royal family retreated to Rio Janeiro, and Brazil developed accordingly. The wealth of Manaus in its heyday due to the global rubber boom is also described in depth (including its opera house *Teatro Amazonas*, and electric trams).

But the Amazon of the last 500 years carries also a history of sexual abuse: "*the gloom of the forest*" "brings out the worst instincts of man, brutalizes the affections, hardens the emotions, and draws out with malign and terrible intention every evil and sordid lust". An entire chapter is devoted to Cabanagem (a local rebellion and revenge against the Portuguese General Company of Commerce resulting in large-scale brutalities and atrocities; it is named after local migrant workers). Many of the sheer brutalities against the natives manifested themselves in the rubber trade. The ones related to the rubber baron J.C. Arana get a chapter of their own, and how W. Hardenburg and W. Perkins exposed single-handedly the human rights violations against the Witoto and Bora tribes in Putumayo. The double standards England played in this context are outlined, too, along with the role of the English Amazon Company. Malaria is basically man-made in South America (probably brought over from Africa from the 16th century onwards by the African slaves and Europeans). Other classic diseases such as beriberi and chagas are mentioned in most chapters. A massive depopulation of the Amazonian river banks was already reported by 1750.

Further, this book is teeming with breathtaking stories about explorers, historical figures, and the cruel colonial history. Five German anthropologists are also given some detail, as well as C. Uncle, the most influential anthropologist of the early 20th century, as well as the Boa Villas brothers. One achievement of their work is that the Xingu tribes can now obtain Brazilian medical treatment. The recent feud centered on the "wonderfully rich varzea" between American anthropologists B. Meggers and A. Roosevelt is outlined. The author has visited many Amazonian tribes himself and is uniquely qualified to put explorations into a native context. And so, a good balance is achieved in this book because it also reports on the infamous Inka and modern native leaders.

The author makes a great case that Europeans did not manage to live sustainably on the land of Amazonia (or elsewhere really). Impacts of the huge but failed investments by American tycoons such as H. Ford in 1927 ("Fordlandia and Belterra"; pioneered by the U.S. Dept of Agriculture and Commerce in 1923) and D. K. Ludwig (1966; softwood and pulp plantations, planned for the world's biggest rice plantation and cattle ranch) are explained. Other American influences in the region are also well described, such as the U.S. attempt to influence Bolivia's rubber region near Acre (controlling 60% of the world's production).

The reader will be further fascinated by the history of the 'Red Bark Tree', *Cinchona*, with the fever bark "that contained the quinine palliative for malaria". C. Markham's involvement in the famous malaria medication, quinine (which got extracted as an alkaloid in 1820 by a French chemist) makes for a great read. The *Cinchona* trees were to be transplanted from South America to India helping to heal the Indian army suffering from malaria. But Peru did not allow the export of the plant because it did not want to lose its valuable monopoly. It was R. Spruce who defeated somewhat illegally the South American countries for the British Commonwealth and with help from Sir W. Huxley from the English Kew Botanical Gardens.

Amazonia represents the lungs of the world. Another fascinating topic deals with the modified forests in Amazona, such as planted palm trees for the acai fruit (*Euterpe oleracea*) as the world's most complete natural food. Timber makes for another precious product, specifically Mahogany (*Swietenia*; with every tree harvested 27 other trees get destroyed). We learn from this book that in 1997, 80% of the logging was illegal, and that selective logging is not working. These things were exposed by A. Cowell's famous work *The Decade of Destruction* exposing the "appalling deforestation, lawlessness and environmental mayhem of the 1980s". Further global awareness of Amazonia's problems were brought by Landsat satellite imagery, and work promoted by NOAA, INPE (Brasil's Space Research Institute), Amazon Research Institute (INPA) and FAO. The World Bank claims an overall 12% loss for Brazil's rainforest (Brazilians lower that estimate to 7%). By now, Amazonia's map shows a bizarre and wide network of reserve systems. Three main reasons for reserves are given in the book: to boost tribal morale, because indigenous people are good custodians of their own land, and because the reserve areas encompass most of the 40 un-contacted tribes.

Brazil is already the world's leading beef exporter. A less known, but equally big problem, is the huge soya-bean plantations. It's a phenomenon brought by high living standards and strong demands, specifically from India and China. The world's wealthiest soya producer, the governor of Matto Grosso, recently built a highway connected with a deep sea port (done without a relevant environmental impact study). Hemming

reports the involvement of U.S. companies such as Cargill.

Brazil was never short of development plans (slogan by politicians: "land without people for people without land"). Hemming concludes in another chapter that the plane, chainsaw and bulldozer did no good for the Amazonian environment. Famous roads and their negative impacts (e.g. Arc of deforestation near BR-10/153 and BR-364) are described. The largest oil find in the Amazonas basin (1964 by Texaco) is explained (but not the recent pipeline issues and that Ecuador became virtually bankrupt). For decades, China and Japan have been asking for access to Amazonia's wealth from the Pacific side. Brazil's latest development plans include the construction of 80 hydroelectric dams (often used for the provision of electricity to mines). The world's largest iron-ore deposit is located near the Xingu river (I think ALCAN gets away in this book with a way too positive image for its impacts). Protective plans for the Amazon such as the Pilot Program to Preserve Brazilian Rainforest PPG7 (set up by the G7 nations), the Sustainable Amazon Plan (PAS) and the System for the Protection of the Amazon (SIPAM) never halted the forest destruction.

When it comes to biology, biodiversity and wildlife management though, the text sections are less strong. This book is rather short on the liberation theology movement. It also must come to the reader as a shortcoming that despite its huge relevance and impact, the infamous *empate* (peaceful removal of squatters), Chico Mendes, Stephan Schwartzman and José Lutzenberger are only mentioned in passing. The role that the English Kew Botanical Garden, and its leader Sir J. Hooker, plays in the brutal exploitation of the Amazon, its people and resources, is indirectly mentioned but not so much how it relates with today's discussion on Bio-piracy, and why Brazil is so reluctant to share with 'the North', and is not fond of the anglophone world and is still lacking trust. The author presents a nice twist, though, by stating that Brazil's coffee industry is based on seeds from elsewhere (Africa) where some of its slave laborers came from. Further, this book does not really cover Brazilian politics well, e.g. impacts of military coups, Brazil's quasi-dictator Vargas and Funai (Ministry of Indigenous People). Also, virtually no reference is made to the huge problems with the World Bank and its destructive funding schemes promoting economic growth. The 17 pages of literature sources I do not find well referenced.

This milestone publication convinces us that the future of Amazonia is in deep trouble. One hopes it will raise awareness for a global betterment of precious natural resources and landscapes, in Amazonia and beyond.

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Plains Apache Ethnobotany

By Julia A. Jordan. 2008. University of Oklahoma Press, 2800 Venture Drive, Norman, Oklahoma. 212 pages. 34.95 USD. Cloth.

Plains Apache Ethnobotany is a delightful book by retired anthropologist Julia A. Jordan. Based on graduate fieldwork she conducted in the mid-1960s in Oklahoma, the book is dedicated to the memory of the Apache elders she and other students worked with during that period – people with whom she developed a working relationship “interlaced with humour and laughter,” as well as apparent mutual respect and cooperation.

The introduction, where Jordan describes the fieldwork and portrays the elders, is one of the most engaging parts of the book. She introduces Ray Blackbear, who was raised by paternal grandparents from whom he learned the history and folklore of the Apache, as well as details on finding and using native plants. He used to tease Jordan unmercifully about her pronunciation of certain Apache words. Louise Saddleblanket, the daughter of a respected Apache medicine man, pierced the author’s ears with a long, carefully selected prickly pear cactus thorn.

Fred Bigman, who lived near the students’ quarters, would never fail to arrive at 7:00 a.m. for his 8:00 a.m. interview, sometimes accompanied by his wife. Sitting quietly in the kitchen, smoking, drinking coffee, and making small talk, he gave the impression that watching the field school students wake up was a favourite pastime. Rose Chaletsin, a woman of property and stature, was an accomplished storyteller who agreed to tell some of her stories during the summer field season, even though the traditional storytelling period is winter. When the recorded stories were played back, the author reports, Chaletsin laughed heartily. Those personal touches set a pleasant tone for the rest of the book.

Part One, “The Plains Apache,” includes a chapter on Plains Apache history and culture, including the earliest known history of the tribe, nineteenth century developments, the reservation and allotment periods, and finally the twentieth century. The chapter on the Plains Apache plant world was particularly intriguing. I discovered, for example, that plants were not conceptualized by the Apache as distinct entities and that the Apache world view did not divide nature into, for ex-

ample, animal, vegetable and mineral kingdoms. The Apache language, writes Jordan, has no equivalent for the English word “plant.” The Apache also conceived of plants as existing in pairs: the “real” plant and an imitation or imitations that resembled the real plant but did not carry its particular properties. Wild bergamot (*Monarda fistulosa*), for example, has imitators within members of the same genus (*M. punctata*, *M. citriodora*) that do not carry *fistulosa*’s highly valued scent.

Part Two, “The Useful Plants,” includes chapters on plants used for food, ritual and medicine, material culture and firewood, and personal care and adornment. What struck me about these chapters was the Apache names for these plants – names that reflect practical knowledge or humorous perception. Wild onion, for example, is called “horses won’t eat it” in Plains Apache, while black samson echinacea is named “medicine makes you numb” because it produces a numbing effect on the mouth tissues when chewed. The ram’s horn or unicorn plant is referred to as “old lady’s toenail,” while the puffball is called “coyote penis.”

In some of the previous paragraphs I have used the past tense to echo Jordan’s writing, as well as her assertion, in the concluding chapter, that although this particular ethnobotany is perhaps incomplete, it would be impossible to replicate now because the elders she worked with have passed away. With the loss, in 2008, of the last individual who could speak the language with any fluency, these “custodians of the language and traditional culture” have, in essence, died out. Nevertheless, Jordan points out, these elders left an enduring legacy for subsequent generations – from the preservation of an important part of their traditional knowledge to their belief in how plants and the rest of the natural world, a powerful and awesome force, should be approached, in the author’s words, “with thoughtful, even prayerful, respect.”

Plains Apache Ethnobotany is a well-written, easy-to-read and informative account about a different sort of relationship with the natural world. Interlaced with the personal stories, experiences and wisdom of Apache elders, it is a must-read for anyone with an interest in traditional ecological knowledge.

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Biodiversity Databases: Techniques, Politics and Applications

Edited by G. Curry and C. J. Humphries. 2008. The Systematics Association Special Volume Series 73. CRC Press, Taylor & B Francis Group, New York. 208 pages. 60.95 USD.

This book is meant to fill a gap in biodiversity, data and informatics. The subject is important for minimizing the digital divide and to make best available use of technology for reaching global sustainability,

environmental justice and increasing human and natural wealth. Not a small feat. As European expertise plays a significant role, the one-sided European view unfortunately carries throughout the book.

Regarding taxonomic and biodiversity data, the authors note that many data are not available as they are predominately published in hard copy, if at all.

The full size of the audience for such information can only be guessed, but making information freely available to China, India, Africa and Brazil would likely see impact factors explode

It's acknowledged that systematics is way behind other disciplines. But the two English editors present no real vision or underlying philosophy why we should move forward. Stopping the taxonomy discipline from crisis and decay with computers, and putting it onto the agenda appears to be a goal of this book and its 10 chapters.

This book is not well edited. The first chapter presents a great overview on the Global Biodiversity Information Facility. GBIF was basically developed through a Mega-Science Forum by the OECD, so GBIF and its data have a commercial agenda. Another chapter (5) deals with the fascinating automated insect and foraminifera identification, but it's a lengthy text. Use of OCR (Optical Character Recognition) is described. Automated tasks involving human expertise show identification reproducibilities as low as 30% or lower". This can put doubts in GBIF data, and some even claim that approximately 60% of all data on public webportals can be wrong!

Another chapter promotes the use of BioCASE (now an adopted GBIF protocol), where the data are globally linked and accessible but where the content remains with the provider. I like specifically the 24h Helpdesk for new BioCASE providers. BIOCISE and ENHSIN are also discussed (the SpeciesAnalyst or Digir platforms are virtually omitted, though). It is clear that the EU virtually has no high-quality, accepted Metadata standard. This is shocking and puts much doubt in the seriousness of the exercise and investment.

Further, the reader will not understand how the European Molecular Biology Laboratory (EMBL) connects with Genbank and with the DNA Database of Japan (DDBJ), and why the world needs different DNA databases to start out with? The Europe-based Expert Centre for Taxonomic Identification (ETI) is described in some detail, but not the global ITIS (Integrated Taxonomy Information System) database.

A key problem in the EU and its various biodiversity networks, projects and competing and fragmented funders is to share and re-use information without duplication (an identified GBIF goal). As GBIF is already located in Europe, one wonders what ENBI (European Network for Biodiversity Information) really does?

The reader interested in the front line of biodiversity will appreciate Chapter 8, which gives a nice overview of LIAS (Information and data storage system for lichenized and lichenicolous ascomycetes) and how it is used with a binary DELTA identification key.

Linking and merging biodiversity databases (Chapter 9) is an interesting and relevant topic, but this chapter lacks entirely the crucial statistical aspects.

This topic has plagued Biodiversity Database from the start and still requires resolution.

Other chapters deal with initial transition problems of the ERMS (European Register of Marine Species) database, with ILDIS (International Legume Database and Information Service), the ILDIS Legume Web, Fishbase and how it all links to SPECIES2000, and then to the infamous Catalogue of Life (linked with North America and cooperating with ITIS). The W3Tropicos database at Missouri Botanical Garden is also discussed, but not so much the Kew Garden one.

A nice point is made that internet use and performance for obtaining valid information can be described with metrics such as precision of information, rigorously correct information recall, time until information is retrieved, etc.

Chapter 10 (Priority Areas for Rattan Conservation on Borneo) makes for a key chapter for the application of online biodiversity databases (Borneo has approximately 8% of the natural vegetation remaining). An optimized area selection method called WORLDMAP gets applied to the data from the ASEAN Regional Centre for Biodiversity Conservation, and interesting data sets are presented for Borneo. It is worthwhile to note here that the EU, or countries like Germany basically, do not have such biodiversity layers for their own states! The book makes clear that relevant ecosystem data are not well represented in these online databases, and the authors kindly, but wrongly, excuse it because of "ecological complexities" (instead of political will). Unfortunately, this book also falls short in its conservation message: Tropical Forest Loss would just be excused as a "complex subject" (instead of being a simple one: just stop the promotion of economic growth and cutting trees), climate change and global warming are separate things, resources are managed by locals and carry no global rights, etc.

This book further shows how inefficient our institutionalized conservation and information management has become, and it's no wonder that our global biodiversity approach needs an entire overhaul. The Consortium of European Taxonomic Facilities (CETAF) is one of the biggest players, but it has a small role in North America. So, the global conservation responsibility of the EU is not well addressed in this book. The notion of world peace cannot be ignored in such discussions. SCAR Antarctic and International Polar Year programs make that clear (but unfortunately are not addressed in this book). What I am missing in this book is a policy and legal chapter (as one would expect from the title).

The georeferencing emphasis for the datasets is nice, but none of the standard tools recommended by GBIF are presented; nor is reference made to altitude information. The presented modeling methods are not based on standard techniques; e.g., ENFA and GARP (a global standard by now) and beyond WorldMap, no other

relevant optimization methods are explained). Instead, authors promote simple GRID arithmetic computations. Some of the presented statistical methods are modern but ignore better or similar relevant methods.

This book leaves us with a one-sided, European (mostly English and German) perspective. African, and even Chinese, Indian, Brazilian, Japanese, Russian, polar and ocean perspectives are widely left out. This book suffers from the missing North American and Australian expertise. This matters because the southern biodiversity community has not forgotten the role that the English Kew Gardens played in "biopirating" when Brazil's rubber monopoly got lost to the Commonwealth.

Many of the URLs are very useful. And this is a strength of this book! Unfortunately, they are often promoting short-lived European initiatives, and are cited inconsistently in the chapters.

This book is not so strong on the technical and software concept. XML is mentioned well, but exact software and code details are not given, The PSE (Problem

Solving Environment) is mentioned, but work benches are hardly touched on. E-Science and GRID technology is mentioned but not how it links with GBIF and its data sources and formats. The Open Access code is not well promoted either. Another flaw is the virtual exclusion of Switzerland (being among the European leaders in biodiversity and habitat data).

It is not only that the book editors are from England, but that of the 24 contributors, virtually all are from the EU (mainly Germany, U.K. and Denmark). Such narrow perspectives are not in the best global, national, tax-payers and biodiversity interest. This book clearly shows what European national academies and scientists can produce; but it is almost a lost opportunity and we need to achieve much better if we care about our data heritage and the globe.

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Local Effects of Global Changes in the Himalayas: Manang Nepal

By R. Chaudhary, T. H. Aase, O. R. Vetaas, and B. P. Subedi.
2007. Tribhuvan University, Nepal and Uniforskning Bergen, Norway. 199 pages. 35 USD.

This book makes for a stimulating contribution to a popular global heritage site: Manang. It presents an overview of its highly dynamic mountain people, and their direct link with globalization, global climate change and the global community as a whole. The study area, located between 4000 – 7000 m altitude and presenting one of the highest agricultures in the world, covers the famous Annapurna Conservation Area.

Unfortunately, this informative book, published with strong Norwegian governmental help, goes along happily with the uncritical notion of economic growth (a scheme that by now has put most of the world in shambles). And so, the Norwegian authors state, wrongly: "There is an emerging consensus that globalization promotes economic growth and prosperity throughout the world". Following the new style of NGO – and development aid-publications, it carries "cool concepts" and some "greenwash", but it often lacks solid data and analysis to back it up.

The 19 contributors (12 Nepali, 6 Norwegians and 1 Canadian), describe a harsh region where contract labor is paid 1.4 US\$ per day. Because of a missing ocean nearby, the lack of selenium and iodine results in a high incidence of Kashin-Beck disease and cretinism. If agriculture declines in this part of the world, out-migration goes up, and so does tourism and the income from it.

A strength of this book is that the authors elaborate on the valuable medicinal plant harvest of Nepal and

other countries in the Hindu Kush-Himalayas (HKH) region. These studies, financially supported by the international corporation of the Volkswagen Foundation, report on over 60 different species of edible mushrooms (including *Morchella* species) for commercial export purposes. Other plant species used are, for instance, *Taxus baccata* and Kutki. "Because of the high global demand and lucrative profit – every age group – were found busy in collecting medical plants". Such an effort cannot be sustainable. Overharvesting increases the price, and thus, the rarity of such plants, which results in a vicious cycle which can easily result in extinction (locally, and even globally).

The Himalayas have approximately 70 big glaciers, which makes for the third largest ice concentration outside of the poles. It supports rivers of global importance such as the Ganges, Brahmaputra and Indus, lifelines for millions of people. Due to man-made climate change; e.g., contamination of the atmosphere through fossil fuel, these glaciers retreat 50 m/year. The Braca glacier will likely disappear very soon (many informative photos are provided; the book overall shows 17 tables) leaving huge impacts. These facts are in direct disagreement with the opening statement of the book that "It would be more realistic to consider mountains as dynamic, certainly not fragile".

A fascinating book topic deals with the fact that much of the traditional Nepali society is based on coexistence, rather than competition. For instance, Amchis (Tibetan healers) provide health care in villages, free of charge! Further, this book helps to expose "the tragedy of the commons" as a myth, because in many parts of the world, resources have been managed successfully for centuries by indigenous institutions!

Although agro-pastoralism is the traditional lifestyle of the Manangi, as early as 1784 they had received special trade privileges from King Rana Bahadur Shah, and their import permits were increased during the 1960s by the late King Mahendra. This invokes strong connections with cities abroad such as Delhi, Shillong, Kalkutta and beyond (e.g., Singapore, Beijing), which are very viable now in times of globalization.

Many of the studies presented are centered on "tsampa, the traditional staple food of the people in Manang". It is made of flour of roasted barley and is served with black tea and yak butter, symbolizing the economic status of the Tibetans.

For agriculture to be successful, good water systems are crucial and thus get well described in the text. "Nutrient management is an important feature of the farming system. No chemical fertilizer is applied". Agricultural systems of Khet (a sophisticated system of cultivated fields) as well as Bari (terraced land) and the traditional Guthi culture are described. Much of the knowledge presented in this book is based, though, on the Dutch geographer van Spengen (1987).

It quickly becomes clear that land tenure is entirely under control of the villagers, but a break with their traditional lifestyle, *parampara*, has already occurred. Whereas traditionally, buckwheat was the "democratic" food, the effect of global agriculture can be seen easily in the study area by the new crop plants that were used in just the last 20 years (e.g. broccoli, carrot, radish, lettuce, onions, green beans). Absurdly, the area still has a larger dependence on imported rice, widely supported through the World Food Program, although Manang could double the local wheat production when better water systems exist. In addition, the book contributors present recent overbrowsing of forests and tree line. The regeneration of vegetation is affected by humans (also varying by type of slope). One concludes that the current treelines are possibly artificially reduced due to human overuse. (This book does not cover the grazing impacts caused by sheep, goats, yak etc.).

Chartered flights from the Manangi region now provide fresh yak meat to Kathmandu. But traditionally, one yak was locally shared among 4, 8, even 16 families. Today "Tourism and trade has introduced globalised food items such as tinned tuna, pizza, peanuts and biscuits"; this is specially obvious with the strongly increased consumption of dried noodles (enjoyed these days by children and adults several days per week). Manang was opened for tourism in 1977, and the authors belabor the fact that, in academic writing, tourism is widely perceived as negative. But then, the famous Badhe Festival got described by the authors to display a "staged authenticity", representing a recent artifact of bi-locality (having a house in Kathmandu as well as in Upper Madang), commercialized religion and global marketing forces for tourism.

By now, most Manangi live outside of Manang. This means a new definition of citizenship, of oneself, and entirely outside of the traditional passport. The problems associated with this bi-locality are widely discussed. "In 20 years from now, most of the inhabitants of Manang will be living in cities like Kathmandu or Pokhara ...". This book does not describe the phenomenon of Western Union banks (which can be seen in high densities in Kathmandu, and elsewhere).

I like chapter 11 (Ethnomedical Plant Use): it's based on four years of fieldwork, co-authored with a Canadian author. It's also great that Common Property Resource (CPR) theory is explained, and that references are made to the Tribhuvan University Central Herbarium (TUCH). But many chapters are just based on one month of fieldwork or less, and are done by Norwegian village outsiders. The nice chapter 3, written by a local author, basically carries most of the relevant information presented in this book, with many of the other chapters being repetitive. A major shortcoming in many chapters, specifically some Norwegian ones, is the lack of described methods (e.g. "I conducted a household survey ..."), as well as digital data, GIS and remote sensing maps, URLs and shared online databases (global standard these days). Some chapters present circular logic or consist of an already published M.Sc. thesis. Rather outdated theories from Torstein Veblen (a Norwegian-American economist who published 1899) are promoted as baselines. Statistical validity of many statements made in this book remain doubtful (correlations, vague hypothesis (if at all), result figures of poor quality; some of the facts are conflicting). Most maps appear to be coarse bitmaps, poorly reproduced. Some relevant soil analysis were not completed because of competing lab interests and performances between Norway and Nepal (inter-laboratory comparisons showed no consistency).

The three-page index of scientific, common (English) and local (vernacular) plant names is helpful; but no accepted taxonomy (e.g., ITIS or IPNI) is used (which is confusing for the international audience and when trying to use findings presented). A four-page general index is provided, as well as a helpful page on acronyms and abbreviations. The reader will appreciate the good collection of literature references (local focus, with many basic North American ones lacking).

"The Intergovernmental Panel on Climatic Change (IPCC) has predicted that the Himalayas in general will get higher annual mean temperatures, more annual precipitation, increased monsoon rainfall, and shrinking areas under snow, ice and permafrost". New grass species; e.g., *Calamagrostis*, have moved into the area already, probably due to climate change. But instead, some authors state naively that global climate change would mean that Scandinavia's agri-

culture could simply harvest more (and grasslands would improve), with Iceland having a double amount of sheep. Similar statements on increased productivity and "positive effects" of climate change are made by the authors for their Nepal study area! Another disturbing topic is the missing demand to stop over-consuming and reduce the wasteful use of fossil fuel and contamination of the atmosphere by the global community. Such omissions are no surprise considering that this project is funded by one of the wealthiest nations of the world is among the biggest oil and gas producers (the book receives the general governmental approval through a Foreword by the Norwegian ambassador who visited Manang briefly). Together with the Volkswagen Foundation funding chapters of economic interest (ethnomedicine to be exploited by the western pharmaceutical industry), the academic involvement of Bergen University promoting uncritically all such concepts needs to be seen as 'dubious'.

The reader will easily find other Norwegian views and biases imposed throughout the text; e.g., "the social landscape of Manangi is at the verge of change and towards attaining a new identity" (instead of stating that it will go extinct, creating much human suffering; a path that in times of globalization many other cultures are already on), or that development of the study area would be driven by social factors, not climate ones (although the latter clearly affects income and resources; e.g., water and growing season length). Consequently, this book falls short on key ingredients for all our survival: appropriate social justice, global village and adaptive sustainable management.

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MISCELLANEOUS

A Mountain Year: Nature Diary of a Wilderness Dweller

By Chris Czajkowski. 2008. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 192 pages. 36.95 CDA.Cloth.

A Mountain Year by Chris Czajkowski is a delight to read and conjures up all the unspoiled beauty of the northern interior of British Colombia. The book is an illustrated journal of a year spent in a retreat away from the rush and mindless bustle of the busy city.

Czajkowski has spent twenty years up at Nuk Tessli, an isolated wilderness region east of Bella Coola, south of Tweedsmuir Provincial Park and five hundred miles north of Vancouver. There are no roads into the area on the western side of the Coastal Mountains, is known as the Charlotte Uplands. The flora ranged from stunted high altitude forest and rises to sub alpine and krummholz.

When Czajkowski first arrived on her own in 1988, there was no cabin there; she logged some trees with her own hands to build the first one. She used chain saws, ropes skids and block and tackle all hauled in by herself. After three years, two more cabins were built and now naturalists and hikers visit in the summer as paying guests. All that is impressive enough but is by no means all the journal teaches us.

This is a journal illustrated by her pen, pencil and watercolour sketches which are both delightful and informative. She has given us the Latin names of the illustrated flowers but not the authority for the names. This is not a book for identification of the plants to below the species level, they do not give enough detail for that, but as paintings they are very artistic. The illustrations of the birds and animals she observed are sketched and full of life and accurate observation. The

sketches give the journal a most personal character. But these illustrations are not the only gifts of this book. Czajkowski is obviously a devoted naturalist and a keen and knowledgeable observer.

The journal takes one through a year in the wilderness, starting at the end of 2004. It conjures up the great sense of silence that can be found in mountain and forests. The minus 22°C can almost be felt. This is a hard, tough life she leads and shares with two dogs. But she is attuned to nature and so observant of the atmosphere, the clouds and colours, the animals, birds and flowers that share the environment with her.

She has no electricity and uses her computer only when the sun has powered her photovoltaic system. She chops and drags trees for her fuel and heating and uses candles for light. To get to her cabin she hikes in several miles from where a small plane has deposited her and her luggage. She uses a sled to carry her luggage to the cabin. Having settled in, she has to get her water. For this in winter, she uses a chain-saw to cut through the ice crust on the lake and draws her water through the hole. There is no easy living here.

Day by day she records the weather and the birds that visit her feeders. At the end of February she gets a flight out, after some delays, to shop for supplies, give some talks, and brush up her first-aid in case it is needed by her guests or herself. The guests start arriving with the summer. Some come from overseas and help with the maintenance of the trails, blazing new ones and other chores. All the while Czajkowski records the flowers as they come into bloom, and paints them; lists the birds and observes their behaviour. Struggling at times with swarms of flies and mosquitoes, she leads

her guests to all the places of interest and teaches them about the ecology, etc. But summer passes quickly and she is alone again to write, paint and update her records and journal. During the fall she flies out to give lectures and to promote her books.

This is a book that teaches one about a life of solitude with nature, about being self-sufficient, and about

one of the unspoiled wilderness areas of British Columbia, of which there are fewer and fewer. I thoroughly enjoyed it and learnt a great deal and recommend it to all nature lovers.

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Choosing Wildness: My Life Among the Ospreys

By Claude Arbour, translated by Joan Irving. 2008. Greystone Books, #201-2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 242 pages. 24.95 CAD Paper.

Choosing Wildness is a book for ornithologists and conservationists to savour. For 20 years, Claude Arbour lived year-round at Lac Villiers, 47° north latitude, in 2500 square kilometres of pristine wilderness far north of Joliette, Quebec. When Arbour first arrived, a pack of wolves occupied the adjacent forest, along with raccoons, pine martens and beaver. Supplies to last the six-month winter isolation had to be transported by boat to the cabin each fall. Emergency travel in winter, if required, was by snowplane or airplane, but during freezeup and breakup, even these modes were impossible for weeks on end. His beloved dog team provided winter transportation; human neighbours were 32 and 40 km distant. On one level, Arbour's tale is one of wilderness survival.

The book, however, is far more than that. It is also an account of the diligence and stewardship of a dedicated naturalist. Aided by sustained contributions from one hundred individual supporters of La Fondation Naturaliste de Lac Villiers, Claude made careful studies of the region's flora and fauna, including over 200 species of birds, and sent each supporter a written report each season. As the subtitle intimates, ospreys soon became one of his main projects. Early on, he built the first of nearly a hundred osprey platforms; the next summer the first of about 200 osprey nestlings fledged; subsequently, between 15 and 20 young fledged each year. One summer he logged 400 hours watching the nearest osprey nest to determine the dates when eggs were laid and later hatched, and when the chicks fledged. He recorded the number and size of fish brought to the osprey nest. Once, when a male osprey disappeared and two of the three chicks had died of starvation, Claude delivered food twice daily for the female and surviving chick, which he banded before it fledged. Once, he threw a fish out over the lake and the female osprey caught it on the fly. Sixty-one of his large osprey platforms persisted until his final survey in 2006; 19 breeding pairs were present that summer.

Injured ospreys and bald eagles were cared for and rehabilitated over long periods, some brought to him by the Union québécoise pour la réhabilitation des oiseaux de proie. Raptor and prey interactions he observed included a bald eagle that chased a Canada goose. Arbour contributed many observations to the provin-

cial database and provides accounts of spotted sandpipers, bald eagles, ravens, pileated woodpeckers, and sightings of a rare prothonotary warbler and Cape May warbler. He also observed a semipalmated plover with three young; however, the location makes it highly improbable that the birds nested locally.

Claude eventually cleared 12 km of winter dog-team and summer hiking trails leading from his cabin to adjacent lakes. One project, building platforms to assist loons in using nests away from the wash of the occasional fisherman's motorboat, was not successful. Sometimes he took extraordinary measures. When the dam at the bottom of the lake burst, Claude placed 150 bags of sand to plug the holes and thus saved the lake's population of northern pike. He also spent 90 hours mapping water depths throughout the lake.

There is more than just a hint of romance. Danielle, a nurse who shared his love of birds, came to visit him. Claude was extremely fortunate that she returned and stayed to share his joy of observing bountiful nature. She was willing to share all the hardships – and pleasures – of an extremely primitive life style. For example, Claude's routine was to have a daily bath in the lake until it froze over. His outdoor privy had a special winter seat sculpted from an insulating material that reflected heat immediately upon contact. He cut 35 cords of wood for fuel each winter. The couple raised two sons in the wilderness; Danielle covered their school lessons in two hours a day, four days a week, until they reached high school age and moved out to Joliette for their schooling. Both boys became self-reliant and trustworthy.

What had Claude and Danielle achieved? Useful data were collected. Platforms encouraged the Osprey population to increase. People were educated to value the wilderness and some shotguns were put away for good as television documentaries about Claude's work were shown across Quebec. Sadly, as the years went by, forested hilltops within view of their cabin were clear-cut and a road reached Lac Villiers, ending their isolation. But on the plus side, the new road allowed Claude and Danielle to take an annual breeding bird survey during their final four years of residence there.

I wish a map had been included, but anyone with a computer can rectify this deficiency by clicking Google Maps, then typing in Saint-Michel-Des-Saints (at the north end of Quebec Highway 131) and then Lac Villiers – in the wilderness about 50 km farther to the

north. The Epilogue, added especially for this translation, tells how Claude was forced to move back south in August 2006 after he became partially disabled by multiple sclerosis.

Rob Sanders of Greystone Books deserves commendation for agreeing to publish this English translation of a book that first appeared in French in 2000. The

compelling story is told in sixty short chapters, averaging only four pages each. An ideal length for a bedside table, much preferable to watching the grisly television news before one turns out the light.

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Return to Warden's Grove: Science, Desire, and the Lives of Sparrows

By Christopher Norment. 2008. University of Iowa Press, 119 West Park Road, 100 Kuhl House, Iowa City, Iowa 52242-1000. Hardcover. 215 pages. 26 USD.

I was attracted to this book because Chris Norment and I share a love of maps, of reading, of banding birds, of subarctic Canadian history, and a special fondness for Harris's Sparrows. We both admired Marguerite Heydweiler Baumgartner, whose 1933 studies of Harris's Sparrows and American Tree Sparrows near Churchill, Manitoba, helped inspire this book. Indeed, *Warden's Grove* is a worthy response to Baumgartner's challenge that "some intrepid young naturalist will elect to fill in the many remaining gaps in our knowledge of this bird of mystery." Norment has produced a fascinating book about studying Harris's Sparrow in what was then one of the remotest spots in the Canadian barren-land wilderness.

Warden's Grove is part of a series of "sightline books", classed by Iowa University Press as "literary nonfiction" – hence, not as science. Personally, I would have preferred a bit more science and less introspection, more hard facts and fewer attempts at self-analysis, but I have already seen two other reviews that praised what I disliked.

Norment first experienced Warden's Grove when he overwintered there in 1977-78, as a member of a six-man expedition that canoed 2200 miles from the Yukon to Hudson Bay. His interest in Harris's Sparrows and romantic recollections of the unrivalled isolation of Warden's Grove led him to return there for three successive summers, 1989 to 1991. The book describes the adventures and difficulties of living in remote Grizzly Bear country, some 310 floatplane

miles from Yellowknife and at that time 180 miles from the nearest human neighbour. This book was written more than a decade after his research, yet he fails to tell us that diamond mines are today just outside the margin of his "nearest-neighbour circle."

While *Warden's Grove* vividly describes the difficulties in research on Harris's Sparrows, it also shares interesting facts about a bird which, in 1931, was the last species in North America to have its nest and eggs discovered. Among other things, we learn that the eggs, laid by females with an average weight of 33.7 g, have an average mass of 3.09 g. The average height of vegetation at the nest is 47.6 cm. Parental feeding rates of the Harris's Sparrow approach 13 trips per hour, compared to 16 for the White-crowned Sparrow. Norment's studies, however, provide no clue to the cause of the decline in wintering Harris's Sparrow populations in the U.S. mid-west. Nor can Norment come up with an answer for how the nestling sparrows stayed almost completely insect free, while he and his assistant were plagued by large numbers of blackflies.

I admire Norment's writing skills. I share his admiration of the Harris's Sparrow, which he describes as unremarkable yet miraculous. I share his concern that our generation lives mostly in a world of noise; that we seek to obliterate time, distance, silence and space; that we demand immediate gratification. *Warden's Grove* is all the more interesting because the wilderness and isolation will soon be no more.

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The Archaeology of Animal Bones – Second Printing

By Terry O'Connor. 2008. Texas A&M University Press, John H. Lindsey Building, Lewis Street 4354 TAMU College Station, Texas 77843-4354. 206 pages. 29.95 USD Paper.

Coincident with reviewing this book, an archaeology class was for the first time using the skeletal collection which I curate, to identify bones from a Mi'kmaq midden. Therefore, I have been getting a pleasant overload of zooarchaeology from two fronts – a thoroughly enjoyable experience. This review, of course, focuses only on Terry O'Connor's ability to convey information and passion about the discoveries, extractions

and problems associated with interpreting past peoples' lives by the animal bones which they left behind.

At just over 200 pages, O'Connor's book is a sampler of many aspects of zooarchaeology; because of its size, it simply cannot go into detail in the chosen topics. The author's own experiences, many of which are appropriately included in these pages, are a valuable contribution and give the book a sense of reality.

The preface has a prosaic passage, "This book is not intended to be a didactic account that explains *how* animal bones ought to be examined and studied.

Instead, the aim is to show *why* this field of scholarship is an important one". In reality, the *why's* were relatively few, and dominantly found in the first chapter, *Why study a lot of old bones?* However, even this chapter barely had any of the promised *why's*. I think the author could have left out this attempt at philosophy and moved right into the down and dirty of zooarchaeology. Ironically, there were a lot of *how's*: many chapters were devoted to *how* archaeologists sort, age, quantify, and more; most methods were treated as overviews (which is appropriate in such a short book), with ample references to the primary literature.

As one would expect in any book on animal bones, there is an early chapter introducing the reader to bone (the material), the bones themselves and the sum of all the bones, the skeletons. Sadly, the orientation diagram of a bird skeleton has two mistakes (the fibula is mislabelled, digits of the manus are misnumbered), not a great start to a book on bones – the second printing, no less. The text of this chapter on orientation to the skeleton contains misleading statements (what is a "higher" vertebrate?) and outright mistakes (e.g., pectoral girdles do not attach the limbs to the vertebral column; caudal vertebrae are not "often reduced to a simple short rod of bone," etc.).

The study of all the events that take a bone from the living animal through to the researcher's bench is known as taphonomy. In addition to orienting the reader to bones, a must-have in a book such as this is an outline of taphonomic processes; without this knowledge, an archaeologist cannot correlate earlier peoples'

use of animals with the bones themselves. O'Connor gives a succinct description of these processes, with several examples (hypothetical and real) to allow the reader to understand that the bones dug up are not exactly as they were dropped by the people who used them.

Many methods used by archaeologists for dealing with animal bones are described, often with both pros and cons explained. Where appropriate, the techniques are compared with those used for working with ancient human remains. O'Connor has also done a good job of bringing in the literature from other disciplines that would clearly bear on the interpretation of, for example, diseases in animals.

This book has not been written for the specialist; my feeling is that it has been written with the interested novice or hobbyist, or perhaps even first year university students in mind. That said, it would have been a very useful addition to have, perhaps on the inside back cover, a geologic time scale; O'Connor liberally uses terms such as *Holocene* and *Neolithic*, terms that are undoubtedly quite meaningful to experts, but in and of themselves, relatively meaningless (other than "old") to the non-specialist. I did enjoy the odd interjection of humour – just like O'Connor's descriptions of his real forays into middens, the humour gave the book personality, a thoroughly appropriate quality.

RANDY LAUFF

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Snakebit: Confessions of a Herpetologist

By Leslie Anthony. 2008. Greystone Books. #201–2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. xi + 292 pages. 29.95 CAD.

There really are two kinds of people: those that like snakes and those that get the heeby-jeebies even at the mention of snakes. Leslie Anthony is certainly in the smaller, but more enlightened, former group. With a PhD specializing in herpetology, Anthony has caught more than his fair share of snakes. In this lively volume, he mixes personal memoir and adventures in exotic locales with a healthy dose of herpetology.

Anthony sets the stage with a prologue of discovering European Adders (*Vipera berus*) while skiing north of the Arctic Circle in Finnish Lapland. From there Anthony takes the reader through adventures more or less chronologically, beginning with childhood hunts for snakes in the suburban wilds of Willowdale and Don Mills, Ontario. Along the way he introduces a veritable who's who of Canadian herpetology.

Anthony completed a master's degree with Dr. Jim Bogart of the University of Guelph, as part of the team working on the genetics of the Blue-spotted Salamander (*Ambystoma laterale*) and Jefferson Salamander

(*A. jeffersonianum*) complex. He gives a detailed explanation of the current understanding of these strange unisexual hybrids, although is somewhat vague about his own work. The most vivid scene from his days in Bogart's lab is being attacked by a two-metre Hispaniolan Boa (*Epicrates striatus*). Anthony continued his work on the Blue-spotted Salamander complex in his PhD studies at the Royal Ontario Museum under the supervision of Dr. Bob Murphy, the "Punk King of Herpetology." Along the way he participated in the world's first phylogenetic rock opera, ROMMY, loosely based upon The Who's rock opera Tommy.

The highlights of the book are Anthony's stories of adventure on collecting expeditions with Dr. Bob: ambushed by bandits in Baja, Mexico, adventures with cobras and kraits along the Khe Moi River of Vietnam, and vipers in Armenia. In between, Anthony finds time to explore the Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) dens in Manitoba and hunt for Northern Pacific Rattlesnakes (*Crotalus oreganus*) in British Columbia.

Anthony abandoned academia for travel and adventure writing, and his journalistic prowess is clearly evi-

dent. Scenes are vividly drawn and his writing style sharp and ironic, although Anthony sometimes becomes too glib, for example, "If continents are the earth's skin, then deserts are a patch of eczema on its butt" (page 132). Some readers will find his fondness for four-letter words unnecessary.

Canadian herpetologists will find this book on Canadian herpetology and Canadian herpetologists essential

reading. And anyone with a healthy interest in snakes or herpetology will find this book from a Canadian, snake-loving Indiana Jones to be a lively, educational and enjoyable read.

DAVID SEBURN

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NEW TITLES

Prepared by Roy John

† Available for review * Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

ZOOLOGY

The Lives of Ants. By Laurent Keller and Elisabeth Gordon. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 252 pages. 50 AUD, Paper.

* **Arctic Fox – Life at the Top of the World.** By G. Hamilton. 2008. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1. 232 pages. 39.95 CAD, Cloth.

A Pictorial Field Guide to the Beetles of Australia: Part four, Bolboceratinae. By Mark R. Golding. 2009. Andrew Isles Natural History Books, 115 Greville Street Prahran 3181 Australia. 40 pages. 30.00 AUD, Paper.

Birds of Eastern Africa. By B. Van Perlo. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 304 pages. 29.95 USD, Paper.

* **Birds of the Horn of Africa – Ethiopia, Eritrea, Djibouti, Somalia, and Socotra.** By Nigel Redman, Terry Stevenson and John Fanshawe. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 488 pages. 40.00 USD, Paper.

* **Birds of East Asia.** By M. Brazil. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 528 pages. 39.95 USD, Paper.

Birds of Europe, Russia, China, and Japan: Non-Passerines: Loons to Woodpeckers. By Norman Arlott. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 256 pages. 29.95 USD, Paper.

Birds of Southern Africa. By B. Van Perlo. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 320 pages. 29.95 USD, Paper.

Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A. J. Paul, E. G. Dawe, R. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, D. Woodby. Alaska Sea Grant College Program, University of Alaska, P.O. Box 755040, Fairbanks, Alaska 99775 USA. 876 pages. 40 USD, Cloth.

Through the Eye of an Eagle: The Bald Eagle in New Brunswick. By Rudolph Stoeck. 2009. Self-Published.

Fifty Years of Flukes and Flippers: a Little History and Personal Adventures with Dolphins, Whales and Sea Lions – 1958-2007. W. Evans. 2008. Pensoft Publishers, Geo Milev Str. No 13a, 1111 Sofia, Bulgaria. 147 pages. EUR 20.00.

* **The ROM Field Guide to Freshwater Fishes of Ontario.** By E. Holm, M. Burrige and N. Mandrak. 2009. Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6. 464 pages, 29.99 CAD, Paper.

Field Guide to the Frogs of Australia. By M. Tyler and F. Knight. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 188 pages. 50 AUD, Plastic.

* **The Frogs and Toads of North America.** By Lang Elliott, Carl Gerhardt, and Carlos Davidson. 2009. Houghton Mifflin Company, 222 Berkeley Street, Boston, Massachusetts. 343 pages. 19.95 USD, Paper.

A Review of Phylogeny and Classification of Gerbillinae (Mammalia: Rodentia). Zoologicheskoe Issledovaniya No. 9. I. Pavlinov. 2008. Pensoft Publishers, Geo Milev Str. No 13a, 1111 Sofia, Bulgaria. 68 pages. EUR 19.

Illustrated Keys to Free-living Invertebrates of Eurasian Arctic Seas and Deep Adjacent Waters; Volume 1. Edited by S. Vassilenko and V. Petryashov. 2009. Alaska Sea Grant College Program, University of Alaska, P.O. Box 755040, Fairbanks, Alaska 99775 USA. 192 pages. 40 USD.

Hunting Tactics of Peregrines and Other Falcons. By Dick Dekker. 2008. Hancock House Publishing. 19313 Zero Avenue, Surrey, British Columbia V3S 9R9. 200 pages. 29.95 CAD, Paper.

Reptiles and Amphibians of the Southern Pine Woods. By Steven B. Reichling. 2008. University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 320 pages. 29.95 USD, Paper.

* **The Beachcomber's Guide to Seashore Life in the Pacific Northwest.** By J. Sept. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. 224 pages. 26.95 CAD, Paper.

Sharks and Rays of Australia (Second edition). By Peter R. Last and John D. Stevens. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 644 pages. 120.00 AUD, Paper.

Shorebirds of the Northern Hemisphere. By R. Chandler. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 448 pages. 90 AUD, Paper.

*** Shorebirds of North America, Europe and Asia.** By R. Chandler. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 448 pages. 35 USD, Paper.

[Editor's note – These two books appear to be the same although there are differences in the press releases (850 vs. 700 photos, 134 vs. 135 species covered) provided by the two publishers]

Snakes: Ecology and Conservation. By Stephen J. Mullin & Richard A. Seigel [Eds.]. 2009. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850. 392 pages. 60.00 USD, Cloth.

*** A Sound Like Water Dripping – In Search of the Boreal Owl.** By Soren Bondrup-Nielsen. 2009. Gaspereau Press, 47 Church Avenue, Kentville, Nova Scotia B4N 2M7. 236 pages, 26.95 CAD, Paper.

*** Squirrels of North America.** By Tamara Eder. 2009. Lone Pine Publishing, 206, 10426 – 81 Avenue, Edmonton, Alberta T6E 1X5. 180 pages. 18.95 USD, Paper.

*** Super Suckers – The Giant Pacific Octopus and Other Cephalopods of the Pacific Coast.** By James A. Cosgrove and Neil McDaniel. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. 208 pages. 26.95 CAD, Paper.

*** Suburban Howls – Tracking the Eastern Coyote in Urban Massachusetts.** By J. Way. 2009. Dog Ear Publishing, 4010W. 86th Street, Ste H, Indianapolis, Indiana 46248. 288 pages. 23.95 USD, Paper.

*** Turtles of the United States and Canada (2nd edition).** By Carl Ernst & Jeffrey Lovich. 2009. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. 840 pages. 95 USD Cloth.

The Wild Mammals of Wisconsin. C. Long. 2008. Pensoft Publishers, Geo Milev Str. No 13a, 1111 Sofia, Bulgaria. 524 pages. 78.00 EUR.

Zooplankton of the Okhotsk Sea – A Review of Russian Studies. Edited by A. Pinchuk and A. Paul. 2009. Alaska Sea Grant College Program, University of Alaska, P.O. Box 755040, Fairbanks, Alaska 99775 USA. 62 pages, 5 USD.

BOTANY

The Metamorphosis of Plants. By J. Goethe. 2009. [Re-print of the 1790 classic book with new illustrations; in English]. The MIT Press, Five Cambridge Center, 4th Floor, Cambridge, Massachusetts 02142-1493. 136 pages. 21.95 USD, Cloth.

*** Les Orchidées indigènes du Québec/Labrador.** By S. Beausejour. 2009. Les Editions Nature, 645 Boulevard Manseau, Joliette, Quebec J6E 3E7. 176 pages. 49.99 CAD, Cloth.

Wildflowers of Southern Western Australia (Third edition, revised). By Margaret G. Corrick and Bruce A. Fuhrer. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 224 pages. 40.00 AUD, Paper.

Wildflowers of Wisconsin and the Great Lakes Region. By M. Black and E. Judziewicz. 2009. University of Wisconsin, 1930 Monroe, Madison, Wisconsin. 320 pages. 29.95 USD, Paper.

ENVIRONMENT

*** Environmental Conflict in Alaska.** By Ken Ross. University Press of Colorado, 5589 Arapahoe Avenue NE. Suite 206C, Boulder, Colorado 80303. 382 pages. 29.95 USD, Paper.

*** Pioneering Conservation in Alaska.** By Ken Ross. University Press of Colorado, 5589 Arapahoe Avenue, Suite 206C, Boulder, Colorado 80303 2006. 540 pages. 34.95 USD Cloth.

*** The Algal Bowl – Overfertilization of the World's Freshwaters and Estuaries.** By David W. Schindler and John R. Vallentyne. 2009. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1. 348 pages, 34.95 USD, Paper.

Proceedings of the Arctic Biodiversity Workshop: New Census of Marine Life Initiative. Edited by K. Iken and B. Konar. 2009. Alaska Sea Grant College Program, University of Alaska, P.O. Box 755040, Fairbanks, Alaska 99775 USA. 164 pages. 7.00 USD.

Australia Saltmarsh Ecology. By N. Saintilan. 2009. Andrew Isles Natural History Books, 115 Greville Street Prahran 3181 Australia. 236 pages. 100 AUD, Paper.

Birdscapes – Birds in Our Imagination and Experience. By J. Mynott. 2009. Princeton University Press, 41 William Street, Princeton, New Jersey. 384 pages. 29.95 USD, Paper.

Defining Darwin – Essays on the History and Philosophy of Evolutionary Biology. By M. Ruse. 2009. Prometheus Books, 59 John Glenn Drive, Amherst, New York. 288 pages. 26.98 USD, Cloth.

In the Wake of the Beagle: Science in the Southern Oceans from the Age of Darwin. By Iain McCalman and Nigel Erskine, editors. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 192 pages. 50.00 AUD, Paper

The Northwest Dive Guide. By M. Hughes. 2009. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. 272 pages. 29.95 CAD, Paper.

*** Ecology of Fragmented Landscapes.** By S. Collinge. 2009. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218. 340 pages. 70 USD, Cloth.

* **Biological Notes on an Old Farm.** By G. Wiggins. 2009. Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6. 359 pages. 45.00 CAD, Cloth.

* **Parks and Nature Places Around Vancouver.** Edited by Alison Parkinson. 2009. Harbour Publishing, PO Box 219, Madeira Park, British Columbia, Canada V0N 2H0. 272 pages 24.95 CAD, Paper.

First Fleet Artist: George Raper's Birds and Plants of Australia. By L. Groom. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 145 pages. 50 AUD, Paper

Seahorses and Their Relatives. By R. Kuitert. 2009. Andrew Isles Natural History Books, 115 Greville Street, Prahran 3181 Australia. 334 pages. 130 AUD, Paper

Speciation and Patterns of Diversity. Edited by R. Butlin, J. Bridle and D. Schluter. 2009. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013. 333 pages. 65 USD Paper, 140 USD, Cloth.

Waterfalls of British Columbia. By T. Greenfield. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0, 208 pages. 26.95 CAD, Paper.

Wild Moments. By M. Engelhard. University of Alaska Press, 794 University Avenue, Suite 220, Fairbanks, Alaska 99709. 248 pages. 21.95 USD, Paper.

News and Comment

Alliance of Natural History Museums of Canada Annual Meeting and Awards 2008

The 2008 annual meeting of the Alliance of Natural History Museums of Canada (ANHMC) was held in Ottawa on 22 and 23 September. This was the fifth anniversary of this network, which was created in 2003 to enhance collaborative work in the areas of research, collections development and education about the natural environment.

A reception was held the evening of 23 September on Parliament Hill, where the second annual Bruce Naylor Award was presented. The award recognizes significant contributions to museum-based natural history in Canada. This year's recipient was Dr. Jon C. Barlow, who held the position of Curator of Ornithology at Toronto's Royal Ontario Museum (ROM) for 35 years until 2001. Over the course of his career, Barlow personally contributed over 6000 specimens to the provincial bird collection, building it into one of the largest in the world, and was a world authority on vireos (small to medium-sized songbirds). Through his combined talents as a researcher, collector, curator, educator, mentor, editor, administrator and larger-than-life personality – he transformed the ornithology program into a flagship department at the ROM. His collaborations included 25 museums around the world and extensive involvement with American and International Ornithological Societies. He also led the University of Toronto's Museum Studies Program. That his efforts elevated the status of Canadian museum-based research in the minds of North American and European aca-

demics is attested to by colleague Dr. James Rising of the University of Toronto and Dr. Bruce McGillivray a former student of Barlow's and now director of the Royal Alberta Museum. The award was accepted by members of Barlow's family as failing health prevented his attendance.

The ANHMC's 13 members from west to north to east are: the Royal British Columbia Museum, Royal Alberta Museum, Royal Tyrrell Museum of Palaeontology, Yukon Beringia Interpretive Centre, Prince of Wales Northern Heritage, Royal Saskatchewan Museum, Manitoba Museum, Royal Ontario Museum, Canadian Museum of Nature, Montreal's Nature Museums (Biodôme, Insectarium, Botanical Gardens and Planetarium), New Brunswick Museum, Nova Scotia Museum of Natural History, and The Rooms Provincial Museum, Newfoundland and Labrador. These institutions are responsible for preserving the record of Canada's natural history through time. Together, member museums safeguard more than 19 million catalogued specimens of plants, animals, minerals and fossils collected over 150 years. The purpose of the national collections strategy is to ensure that this crucial record is complete and is preserved in perpetuity. Pauline Rafferty, President of the ANHMC and Director of the Royal British Columbia Museum, stressed that the member institutions are "... working on a national strategy for developing a collection that will represent all of Canada's biodiversity."

USA National Phenology Network

The USA National Phenology Network (USA-NPN) monitors the influence of climate on the phenology of plants, animals, and landscapes. They encourage people to observe phenological events like leaf out, flowering, migrations, and egg laying, and provide a place for people to enter, store, and share their observations. They also work with researchers to develop tools and techniques to use these observations to support a wide range of decisions made routinely by citizens, managers, scientists and others, including decisions related to allergies, wildfires, water, and conservation.

The USA-NPN is comprised of many partners, including federal, state and local agencies, universities, colleges and schools, non-governmental organizations, and volunteers. Participants range from individual ob-

servers making observations in their backyards to professional scientists monitoring long-term plots.

The efforts of the USA-NPN are organized and directed by the staff at the USA-NPN National Coordinating Office at the University of Arizona, with support from the U.S. Geological Survey, the National Science Foundation, and many other funding agencies, organizations, and partners. The USA-NPN is governed by an executive committee consisting of a 12-member Board of Directors, the NCO Executive Director, and Assistant Director, as specified in its constitution. Several working groups have also been established within the USA-NPN to address specific issues within the field of phenology.

Marine Turtle Newsletter (122) October 2008

28 pages: ARTICLES: An introduction to Bayesian statistics without using equations (T. Eguchi) — Ebiobionts associated with Green Sea Turtles from Cananéia, Brazil (B. Oliveira De Loreto and C. V. Bondioli) — Analysis of a live stranded Leatherback, *Dermochelys coriacea*, in Brazil (M. R. Werneck, G. H. P. Dutra, and B. M. G. Gallo) — NOTE: Juvenile Hawksbill tagged in The Bahamas nests in Tobago K. A. Bjoundal, T. Clovis, K. J. Reich, G. Alkins, P. J. Ellazar, and A.B. Bolten) — LETTER TO THE EDITOR — BOOK REVIEW — MEETING REPORT — ANNOUNCEMENTS — IUCN-MTSG QUARTERLY REPORT — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

Ontario Crayfish

This attractive identification brochure condenses a multitude of information. It is printed on glossy-finished cardboard for durability in field use. Ten species are depicted in exquisite detail in lateral view in colour by Aleta Karstad, seven native, one spreading westward from Quebec in the St. Lawrence River, and two introduced. Brief range, maximum size, behaviour and or habitat notations are given. Black-and-white diagrams by Parmek Hamr compare dorsal views and detail the rostrum, chelaë, carapace, abdomen and cop-

The Marine Turtle Newsletter is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, NC Sea Turtle Project, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <<http://www.seaturtle.org/mtn/>> or postal mail to Michael S. Coyne (Managing Editor), Marine Turtle Newsletter, A321 LSRC, Box 90328 Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: mcoyne@seaturtle.org.

ulatory stylets. There is a labelled diagram of "the shape of crayfish", and a map showing the number of species in various Ontario regions. Brief statements are given on the ecological importance, possible disappearance, lifestyle, and how to find crayfish. More information is available at www.crayfishontario.ca.

Production has been supported by the Bishops Mills Natural History Centre, Ontario Nature (Federation of Ontario Naturalists) and the Toronto Zoo.

Canadian Association of Herpetologists Association canadienne des herpetologues Bulletin 16(1) Fall 2008

CONTENTS: Instructions for Authors — EDITORIAL NOTES — MEETINGS: Northeast Natural History Conference, Albany New York 16-18 April 2008 (Shane de Solla) — Joint Meeting in Herpetology in Montreal 23-28 July 2008 (Leslie Anthony) — FEATURE ARTICLE: Keeping the 'Herps' in Herpetology: Is the use of live animals in teaching being threatened? (Stephen Hecnar) — FIELD NOTES: What the heck happened to that thing? Tales from the field notes of a turtle biologist (Amanda Bennett) — BOOK REVIEWS: Review of *The Ecology and Behavior of Amphibians* by K. Wells 2007 (Richard Wassersug) — Review of *Malformed Frogs* by M. Lannoo 2008 (Janet Koprivnikar) — THESIS ABSTRACTS IN CANADIAN HERPETOLOGY: Christine Baptista BSc 2007, Lakehead University, Thunder Bay, Ontario, *The effects of environmental variables on five-lined skink (Eumeces fasciatus) abundance in Point Pelee National Park* (Supervisor: Stephen Hecnar); Pascale Belleau MSc 2008 McGill University; Montreal, Quebec, *Habitat selection, movement patterns, and demography of the common musk turtle (Sternotherus odoratus) in south-western Quebec* (Co-supervisors: Gabriel Blouin-Demers and Roger Titman); Nicholas A. Cairns BSc 2008 Brandon University, Brandon, Manitoba, *A comparison of habitat usage and seasonality of the smooth green snake (Liophorophis vernalis) and the northern*

red-bellied snake (Storeria occipitomaculata occipitomaculata) (Supervisor: Pamela Rutherford); Kel P. Cullis BSc 2008 Lakehead University, *A comparison of herpetofaunal monitoring methods for use in the Thunder Bay, Ontario, District* (Supervisor: Stephen Hecnar); Christopher B. Edge MSc 2008 Laurentian University, Sudbury, Ontario, *Multiple scale habitat selection by Blanding's Turtles (Emydoidea blandingii)* (Supervisor: Jacqueline Litzgus); Felix Eigenbrod PhD 2008 Carleton University, Ottawa, Ontario, *Measuring the effects of forest extent and road traffic on anuran populations* (Co-supervisors: Stephen Hecnar and Lenore Fahrig); Karen Elgee BSc 2008 University of Ottawa, Ottawa, Ontario, *Sexual size dimorphism in garter snakes (Thamnophis sirtalis), water snakes (Nerodia sipedon) and black ratsnakes (Elaphe obsoleta)* (Supervisor: Gabriel Blouin-Demers); Dale M. Jefferson MSc 2008 Saint Mary's University, Halifax, Nova Scotia, *Stable isotope characterization of community trophic structures in assemblages of aquatic and terrestrial herpetofauna* (Supervisor: Ronald Russell); Megan K. Johnson MSc 2008 University of Calgary, Calgary, Alberta, *Relationships between setal field and natural substratum microtopography in the genus Rhoptropus (Gekkota: Gekkonidae) in Namibia, Southern Africa* (Supervisor: Anthony Russell); Kristen L. Keyes BSc 2007 Lakehead University, *Effects of envi-*

ronmental variables on calling in Ontario anurans (Supervisor: Stephen Hecnar); Lucy Paterson BSc 2007 University of Ottawa, *The effect of constant vs. fluctuating incubation temperatures on the phenotype and fitness of the black rat snake* (*Elaphe obsoleta*) hatchlings (Supervisor: Gabriel Blouin-Demers); Gabriel Picard BSc 2008 University of Ottawa, *Does thermal quality of the environment affect habitat selection by musk turtles* (*Sternotherus odoratus*)? (Supervisor: Gabriel Blouin-Demers); Candra Schank

MSc 2008 University of Alberta, Edmonton, Alberta, *Assessing the effects of trout stocking on native amphibian communities in small boreal foothills lakes of Alberta* (Supervisor: Cindy Paszkowski) — RECENT PUBLICATIONS IN CANADIAN HERPETOLOGY — NEWS AND ANNOUNCEMENTS — MEMBERSHIP FORM.

The CAH-ACH Bulletin is edited by Jacqueline D. Litzgus, Department of Biology, Laurentian University, Sudbury, Ontario P3E 2C6, jlitzgus@Laurentian.ca.

The Ottawa Field-Naturalists' Club Awards for 2007

IRWIN M. BRODO, CHRISTINE HANRAHAN, DIANE LEPAPE, AND ELEANOR ZURBRIGG

On 26 April 2008, members and friends of the Ottawa Field-Naturalists' Club gathered at the Club's Annual Soirée at St. Basil's Church in Ottawa, and once again, awards were given to members, and one non-member, who distinguished themselves by accomplishments in the field of natural history and conservation, or by

extraordinary activity within the Club. Careful observation of plants and animals, political savvy, selfless service, and teaching skills are all in evidence among this year's winners. The following citations for those who received an award were read to the members and guests assembled for the event.

Member of the Year – Carla Hilado

The Member of the Year award is given in recognition of a member who has contributed significantly to the Club in the previous year. Carla Hilado has worked at the Fletcher Wildlife Garden (FWG) for three years, and during that time has assumed more and more responsibilities, offering to help where needed, making practical suggestions, and initiating projects.

Carla joined the OFNC in 2001. In 2005 she joined the Backyard Garden (BYG) group, which meets each Friday morning throughout the gardening season at the Fletcher Wildlife Garden. She was interested in gardening and networking with other naturalists. As a recent graduate of the University of Guelph with a degree in Wildlife Biology, she felt that she could contribute to the FWG and, at the same time, learn from others. She soon discovered that this was indeed a great learning opportunity amidst wonderful company and so she decided that she would like to contribute more to other areas of the garden, as well as continuing to work in the BYG.

One of the FWG projects that caught her eye was the creation of a new addition to the Butterfly Meadow. A newly formed group began meeting on Wednesday evenings. In addition to planting wildflowers, she devoted a great deal of effort to controlling the invasive pale

swallowwort (dog-strangling vine.) Removal of this plant is not everyone's cup of tea, but Carla has been a constant and persistent hard-working presence, dedicated to making sure that the newly planted wildflowers are not over-run by the swallowwort. In 2007, she and other garden volunteers began work on mapping the Butterfly Meadow, and collecting and preparing seeds. Carla has also helped in removing invasive plants from the FWG Amphibian Pond.

Recently, Carla initiated organization of all the FWG brochures and information sheets. She created a spreadsheet that keeps track of the number of brochures and information sheets FWG has for distribution. Using this system makes it easier to establish how many of these items have been used and when the stock needs replenishing. This very organized system is a wonderful innovation for the FWG.

Carla's quiet presence and unassuming air sometimes leads one to overlook the work that she does. But she has contributed much to the garden, is a reliable and careful worker, and is absolutely dependable. She is also a real pleasure to work with. For all these reasons, we are proud to give Carla Hilado the OFNC's Member of the Year award.

George McGee Service Award – Louis L'Arrivée

The George McGee Service Award is given in recognition of a member who has contributed significantly to the smooth running of the Club over several years. For the past eight years, Louis L'Arrivée has been responsible for the mailing of the OFNC publication, *Trail & Landscape* (T&L). Louis is a person who works "behind the scenes" and most members of the Club might not have heard of him or know about the amount of time he puts into organizing the mailing of *Trail & Landscape*.

Four times a year he takes action. It begins with the notification of the proposed date when T&L will be ready for mailing. Louis gets the ball rolling by contacting the membership committee chair for the current address list, and then he organizes the people who

assist him in the mailing. Prior to the mailing, he sorts and bundles the hundreds of mailing labels by postal code in order to ascertain the appropriate number of Canada Post containers and the correct machine readable postal codes. This ensures the publication is in the correct format to allow Canada Post to use its quick mailing process. He also makes sure there are enough peripheral supplies for the mailing to run smoothly and will often confirm with the editor and the printer concerning the correct T&L mailing date.

Louis allows the use of his home for us to complete the necessary tasks for the mailing to take place. He is always well organized; everything is ready for us upon arrival. If someone is new to the group, he patiently explains the process and is willing to answer any

question or offer any suggestions to help streamline the activity. The more unusual mailings, such as the international addresses requiring special attention, are always done by Louis personally. All this is conducted in a very warm, hospitable environment. His kindness and patience make it always a pleasure to assist in the mailing exercise.

When all the publications are ready for mailing, Louis prepares the Mailing Summary and brings the containers to the main post office (not all postal out-

lets will accept pre-sorted mail containers), often on a Monday morning before he begins his work day.

Louis has been known to do all of this on very short notice, and at times re-arrange his weekday evenings to attend to the mailing when his weekends are filled with family activities. One notable mailing date was December 26, a testament to Louis' dedication.

For his outstanding service over many years, the OFNC is pleased to present the George McGee Service Award to Louis L'Arrivée.

Conservation Award — Non-Member – Cliff Bennett

This award is given in recognition of an outstanding contribution by a non-member (or group of non-members) in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

Cliff Bennett is the recipient of this award for 2007, recognizing his contributions over many years to natural history conservation within the Ottawa Valley and in particular in the area of Almonte/Carleton Place. Cliff has demonstrated a sustained commitment to protection of the environment and has tirelessly worked over many decades to help people enjoy, understand and respect the natural world.

Cliff is a founding member of the Mississippi Valley Field Naturalists (in 1988), where he has held various offices including President and Director for many years, and sits on key club committees. He is in large part responsible for the growth and influence of the club over the years, and has worked ceaselessly to ensure that MVFN activities increase the environmental awareness of citizens. For example, Cliff established the MVFN's warmly received Environmental Education Projects Program (EPPP), which helps fund class field trips, visiting speakers and presentations on environmental topics in area schools. He also encouraged the MVFN to take on an ambitious Climate Change Awareness Project. Cliff helped develop a very popular guide to canoe outings and trail hikes complete with descriptions; these guides are posted on the MVFN website.

An avid birder, Cliff writes an excellent and very popular column, 'Speaking of Birds' for the *Lanark Era* newspaper, something he has done for many years. He coordinates the Carleton Place Christmas Bird Count, participates in the Baillie Birdathon to raise funds for bird research and conservation, and was instrumental in organizing participants of the MVFN for the Ontario Breeding Bird Atlas.

As a nature conservation advocate, Cliff has been influential on the Board of Directors of Ontario Nature, representing Eastern Ontario groups since 2005. He has been extremely busy and effective in this capacity, and local naturalist groups have already benefited from having such an articulate, informed and persuasive representative to the provincial conservation body. He also provided thoughtful environmental input into the new Community Official Plan for Mississippi Mills, helped to start up the Mississippi Madawaska Land Trust Conservancy to protect valuable natural areas in the region, participated on the Environmental Advisory Committee for the Lanark Highlands, effectively advocated for public trails in Lanark County, and was instrumental in establishing the North Lanark Trails Advisory Committee.

Cliff's active involvement in and commitment to natural history and conservation issues are long-standing, and shows no signs of waning. We are really fortunate to have such a dedicated and effective spokesperson for the conservation of our natural world.

Conservation Award — Member – Erwin Dreessen

The OFNC Conservation Award is given in recognition of a club member who has made an outstanding contribution toward protecting our natural environment in the Ottawa Region. Erwin Dreessen has been a prominent and vocal defender of urban greenspaces for many years. He has written articles, prepared reports, given presentations, and argued in a lucid and thought-provoking manner for the preservation and protection of natural areas in the nation's capital.

Erwin first became involved in land use issues in 1993, galvanized into action by development proposals for the Confederation Heights area. As a member of the Federation of Citizens' Associations, he served as Chair of their Land Use Committee.

From these beginnings, Erwin went on to help found the Greenspace Alliance (GA) in 1997, a very active and well-regarded citizen's group. He was Chair of the organization for several years as well as a director, and is now one of the moderators of the GA listserve. He continues to play a major role in the organization. One of his main functions has been to advance greenspace issues in the City of Ottawa Official Plan, advocating for retention and protection of wetlands, woodlots and other natural areas in the urban context. This is no small role. He monitors City development proposals, attends hearings and meetings with City staff, attends all OMB hearings in which greenspace issues are a factor, and prepares reports on same for the GA listserve.

As a fellow Greenspace Alliance member noted, Erwin is a stickler for detail and accuracy, and his research is thorough. This ensures that the GA is always exceptionally well prepared when advocating the protection and preservation of Ottawa's greenspace, and such thoroughness has earned them much respect and attention.

A long-standing concern for Erwin has been the Southern Corridor, which includes McCarthy Woods. He has spent considerable time reviewing consultant's reports, Ottawa's Urban Natural Areas study, and liaising with other groups and individuals, arguing for the protection of the entire Southern Corridor, including the extensive meadow habitat. The meadow is significant both for wildlife and as a component of the Poets' Pathway project. The Poet's Pathway, a tribute to the nature-inspired Confederation Poets, envisages

a pathway spanning the greenspaces of urban Ottawa.

Erwin was also very involved in helping prevent a golf course at Leamy Lake. As well, he has played a significant role in the Ottawa Land Trust projects. OFNC members may also remember Erwin's recent article in *Trail & Landscape* (July-September 2007) on NCC holdings outside Gatineau Park and the Greenbelt. This quite exhaustive article is a must read for those who wish to understand more clearly the land acquisitions and disposals of the NCC.

Erwin Dreessen is a tireless champion of our urban natural areas, and his work is of the utmost importance to those who value greenspace preservation. For all his work on these issues, we are proud to present Erwin with the OFNC's Conservation Award – member for 2007.

Anne Hanes Natural History Award – Ross Layberry

The Anne Hanes Natural History Award recognizes excellence in natural history research by an amateur. This year the award goes to butterfly enthusiast and expert, Ross Layberry.

Ross shared the first Anne Hanes Natural History Award in 1982 with J. Donald Lafontaine and Peter Hall for writing the "Butterflies of the Ottawa District." (*Trail & Landscape* volume 16, number 1). Sixteen years later this triumvirate wrote the seminal book *Butterflies of Canada* published by University of Toronto Press.

This year we are recognizing Ross for his recent article in *Trail & Landscape* (volume 41, number 1), "Butterflies of the Ottawa District: 103 species...and counting." As this article testifies, Ross has continued over the years to be a keen field observer, meticulous collector of data, discriminating collector of specimens, and even a careful rearer of immatures. This has enabled him to fill in many gaps in our knowledge of the butterflies and, more importantly, to make that information available to all through his lucid writing. In the article, Ross explains why four species should no longer be included in the Ottawa butterfly fauna, and

why several others should be added. Most fascinating and impressive were the descriptions of his successful (and less successful) attempts at rearing the larvae of certain taxonomically problematic species such as the Summer Azure and Cherry Gall Azure in order to better understand the species' limits. This kind of careful, often frustrating work goes far beyond the ordinary "capture and list" activity of most butterfly collectors.

In addition to preparing well-written articles, Ross has made a very special contribution to our knowledge of local butterflies by his meticulous work in creating and maintaining a database of thousands of records of butterflies that is now available through the Canadian Biodiversity Information Facility under the auspices of Agriculture and Agri-Food Canada in Ottawa. This database is readily accessible to researchers and amateurs online.

Ross has been collecting butterflies since he was a child in England. He simply continued that interest as an amateur when he came here as a young man. He has become a leading expert in Canadian as well as local butterflies. We are pleased to present him with the Anne Hanes Natural History Award for 2007.

Mary Stuart Education Award — Martha Webber

The Mary Stuart Education Award was established to recognize members, non-members or organizations, for their outstanding achievements in the field of natural history education in the Ottawa Region. The OFNC is pleased to give the award for 2007 to Martha Webber.

Martha Webber is much sought after by the Girl Guides, Boy Scouts, home schooling groups and others as a respected nature interpreter and resource person. Martha is an active member of the Council of Outdoor Educators of Ontario. Her study of native beliefs has encouraged her to know that people of all ages are com-

fortable in the out of doors when they acknowledge their kinship with nature.

Martha has a Masters degree in botany from the University of New Hampshire. While at the University of Wisconsin, she worked at various conservation camps as a counsellor, and attended the Ranger Naturalist Training School in Yosemite National Park. At the latter, she was involved with a myriad of wildlife studies, including banding bats and participating in an annual bird census. She taught high school biology for six years in Vermont, where she was involved with

the development of the then new science of ecology. Eventually she and her family moved to rural Kanata, where she has lived for the last 30 years. It is here in her spacious gardens and adjacent natural areas that she runs many of her botany and natural history courses.

For a number of years Martha participated in the Ottawa Valley Field Trips, leading tours and giving courses on botanical subjects. Environmental programs for schools and other groups, nature day camps and back roads bus tours were some of the many activities Martha worked on.

Her summer nature interpretation day camps, *Look and Listen Nature Camps*, are limited to twelve children per group, and focus on personal awareness programs such as Project Wild and Tom Brown Junior's field exploration.

Martha also teaches courses in basic botanical identification as well as a six-week course in Edible Wild Plants that always ends with a wild food banquet. As well, she shares her knowledge of how native peoples used plants both for food and for medicine. In other courses, she instructs participants in the ecology of natural areas, discussing the interconnectedness of all things. Martha gives freely of her time to lead field trips for not-for-profit groups, taking people to some of the special wild places in our region. She continues to actively pursue protection for the Carp Ridge by conducting guided walks in the area, speaking to interested groups, writing letters, and meeting with politicians.

Martha has worked quietly and competently for many, many years, and it is time that she was recognized for this tremendous contribution to the study of natural history.

Index to Volume 122

Compiled by Leslie Cody

- Aaboe, K., 247
- Abies balsamea*, 118,169,213,226,231
grandes, 52
lasiocarpa, 206
- Acer* sp., 120,226
negundo, 228
platinoides, 226
rubrum, 113,228
rubrum var. *rubrum*, 19
saccharinum, 228
saccharum, 118,153,213,228
saccharum var. *saccharum*, 18
spicatum, 19,118
- Achillea lanulosa*, 17
millefolium var. *occidentalis*, 17
- Actaea pachypoda*, 19
rubra ssp. *rubra*, 19
- Agalinis tenuifolia*, 106
- Agelaius phoeniceus*, 22
- Agelenopsis potteri*, 111
- Agkistrodon mokasen*, 73
- Agrimonia gryposepala*, 18
- Agropyron cristatum*, 346
repens, 346
spicatum, 346
- Agrostis scabra*, 19
- Agrotus vestula*, 109
- Agueweed, 8
- Alaska, Evidence for Higher Soil Temperature and Potassium Promoting Invasion of the Common Dandelion, *Taraxacum officinale*, in Denali National Park and Preserve, 67
- Alaska, Nesting Biology of Lesser Canada Geese, *Branta canadensis parvipes*, along the Tanana River, 29
- Alberta, and Wyoming, Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, 76
- Alberta, Bullsnake, *Pituophis catenifer sayi*, Nesting-Biology in, 138
- Alberta, Evidence of Arboreal Lichen Use in Peatlands by White-tailed Deer, *Odocoileus virginianus*, in North-eastern, 230
- Alberta, Evidence of Raccoon, *Procyon lotor*, Range Extension in Northern, 176
- Alberta, Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central, 179
- Alberta, within Differing Habitats and Management Intensity Levels, The Density of Beaver, *Castor canadensis*, Activities along Camrose Creek, 299
- Alces alces*, 50,77,173,179,231,273,324
- Alder, 30,301
 Rough, 118
- Alectoria* sp., 231
nigricans, 200
ochroleuca, 200
- Alfalfa, 346
- Allonemobius griseus griseus*, 110
- Alnus* sp., 30,301
rugosa, 118
- Amara quenseli*, 109
- Ambloplites*, 305
rupestris, 303
- Ambrosia artemisiifolia* var. *artemisiifolia*, 18
psilostachya, 113
- Amelanchier* sp., 212
alnifolia, 52
arborea var. *arborea*, 18,116
bartramiana, 214
laevis, 18,106
sanguinea var. *sanguinea*, 18
stolonifera, 6,106
- American-aster, New England, 18
- Purple-stem, 19
- Sky-blue, 16
- White Arrow, 16
- White Health, 16
- Ammocrypta pellucida*, 239
- Ammocrypta pellucida*, in Two Lake Champlain Tributaries, Habitat Use by the Eastern Sand Darter, 239
- Ammodramus savannarum*, 111
- Ammodytes* sp., 340
- Ammophila* sp., 110
harti, 110
kennedyi, 110
urnaria, 110
- Amphicarpaea bracteata* var. *bracteata*, 18
- Anaphalis margaritacea*, 17,116
- Anaxyrus*, 94
americanus, 160
- Andersen, D.E., 129
- Andropogon* sp., 106
gerardii, 6
virginicus var. *virginicus*, 19
- Anemone cylindrica*, 7,106
quinquefolia, 8
quinquefolia var. *quinquefolia*, 19
virginiana var. *virginiana*, 19
- Anisodactylus* sp., 109
merula, 109
rusticus, 109
- Antelope-brush, 346
- Antennaria howellii* ssp. *petaloidea*, 17
parlinii ssp. *fallax*, 18
- Apeltes quadracus*, 340
- Apocynum androsaemifolium*, 16,116
- Aquila chrysaetos*, 268
- Aquila chrysaetos*, Nest, Egg Predation at a Golden Eagle, 268
- Aquilegia canadensis*, 17

- Arabis divaricarpa*, 6
 glabra, 6
 hirsuta var. *pyncocarpa*, 6
 holboellii var. *retrofracta*, 6
- Aralia hispida*, 212
 nudicaulis, 18,212
 racemosa, 214
- Arborvitae, Eastern, 18,117
- Archilochus colubris*, 154
- Arctostaphylos alpina*, 214
 uva-ursi, 6,214
- Ardea herodias*, 73
- Arenaria serpyllifolia*, 19
- Aristida basiramea*, 113
- Arrow-wood, Downy, 19
 Maple-leaf, 18
- Artemisia campestris*, 8
 campestris ssp. *borealis* var. *scouleriana*, 6
 norvegica, 346
 tridentata, 53,346
- Asclepias exaltata*, 7
 syriaca, 7,116
 tuberosa, 12
 tuberosa ssp. *tuberosa*, 6
- Ash, Mountain, 212
 Prickly, 20
- Asher, V.J., 76
- Aspen, 61,205,222,265
 Big-toothed, 18,265
 Quaking, 17
 Trembling, 52,117,173,176,179,205,228,231,299
- Aster macrophyllus*, 18
- Aster, Amethyst, 20
 Wavy-leaf American, 8
- Astrytone logan* ssp. *logan*, 109
- Aulacomnium palustre*, 200
 turgidum, 200
- Avens, White, 20
 Yellow, 20
- Aythya affinis*, 21
 valisineria, 24
- Aythya americana*, 24
- Aythya affinis*, Eye Colour, Aging, and Decoy Trap Bias in Lesser Scaup, 21
- Baccharis pilularis*, 80
- Badger, American, 111
- Ballard, W.B., 253
- Balsamorhiza sagittata*, 346
- Balsamroot, 346
- Baneberry, Red, 19
 White, 19
- Bangs, E.E., 76
- Bass, Black, 303
 Rock, 303
- Basswood, American, 19
- Bastard-toadflax, 17
- Beamish, R.J. and J. Wade. Critical Habitat and the Conservation Ecology of the Freshwater Parasitic Lamprey, *Lampetra macrostoma*, 327
- Bear, American Black, 111,167
 Black, 71,212
 Brown, 77
 Grizzly, 31,76,172,272,323
 Polar, 132,324
- Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming, Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly, 76
- Bearberry, Red, 17
- Beard, Old Man's, 231
- Beardtongue, Foxglove, 20
 Hairy, 17
- Bears, *Ursus americanus*, in Quebec, Factors Influencing the Abundance of Berry Plants for Black, 212
- Bears, *Ursus arctos*, in Wapusk National Park, Northeastern Manitoba, Grizzly, 323
- Beaver, 31,169,173,176,299,308
- Beaver, *Castor canadensis*, Activities along Camrose Creek, Alberta, within Differing Habitats and Management Intensity Levels, The Density of, 299
- Bedstraw, Licorice, 18
- Beetle, 78
 Mountain Pine, 205
 Tiger, 109
- Beetle Remains Discovered in a Pellet from a Great Gray Owl, *Strix nebulosa*, Nest, Dytiscid, 78
- Beier, P., 49
- Bembix* sp., 110
 americana spinolae, 110
 pallidipicta, 110
- Bent, Rough, 19
- Berberis repens*, 52
- Bergamot, 1
- Bergman, C., 76
- Bertram, S.M., 73
- Betula* sp., 120
 alleghaniensis, 118,213
 papyrifera, 116,118,173,213,301
 papyrifera var. *papyrifera*, 19
 populifolia, 106,169
- Bindweed, Low False, 16,116
- Birch, Gray [Grey], 116,169
 Paper, 19,73,116,213
 White, 118,301
 Yellow, 118,213
- Biro, P.A. and M.S. Ridgway. Repeatability of Foraging Tactics in Young Brook Trout, *Salvelinus fontinalis*, 40
- Bison bison*, 171,180
- Bison, 171,180
- Bison bison*, Allonursing and Cooperative Birthing Behavior in Yellowstone Bison, 171
- Bison, *Bison bison*, Allonursing and Cooperative Birthing Behavior in Yellowstone, 171
- Bittersweet, American, 19
- Black-eyed-Susan, 17,109
- Black-snakeroot, Maryland, 19
- Blackberry, Allegheny, 17,117
- Blackbird, Red-winged, 22
- Blarina brevicauda*, 120
- Blue-eyed-grass, Strict, 18
- Bluebell-of-Scotland, 17
- Blueberry, 212,324
 Highbush, 8
 Late Lowbush, 17
 Lowbush, 8
- Bluestem, Big, 16
 Little False, 17
- Boal, C.W., 129
- Bobcat, 167

- Bombycilla cedrorum*, 154
Bonasa umbellus, 169
Boreal Dip Net / L'Epuisette Boreal, The, 194
Botrychium dissectum, 8
 multifidum, 7
 obliquum, 8
Botrylloides violaceus, 342
Botryllus schlosseri, 342
 Boutin, S., 230
 Bracken, 117
Branta canadensis, 29, 134, 324
 canadensis moffitti, 31
 canadensis parvipes, 29
 hutchinsii, 36
 hutchinsii hutchinsii, 29
 hutchinsii minima, 29
 hutchinsii taverneri, 29
 ruficollis, 32
Branta canadensis parvipes, along the Tanana River, Alaska, Nesting Biology of Lesser Canada Geese, 29
 British Columbia, Abundance Trends for *Hexanchus griseus*, Bluntnose Sixgill Shark, and *Hydrolagus colliei*, Spotted Ratfish, Counted at an Automated Underwater Observation Station in the Strait of Georgia, 124
 British Columbia, Dynamics of Peripheral Populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in Southern, 345
 British Columbia, Late-Winter Habitat Use by Mule Deer, *Odocoileus hemionus*, in Central Interior, 205
 Brome, Downy, 346
 Hairy Woodland, 18
 Kalm's, 17
 Smooth, 104
Bromus inermis, 8, 99
 kalmii, 6
 pubescens, 18
 tectorum, 346
 Brook, R.W., 21
 Broom-rape, Naked, 20
 Broom-sedge, 19
Bruant hudsonien, 156
 Bruant, 154
 à gorge blanche, 156
 chanteur, 157
 Brush, Coyote, 80
Bryocaulon divergens, 200
Bryoria sp., 200, 231
 fremontii, 200
 friabilis, 201
 lanestris, 200
 nadvornikiana, 202
Bubo virginianus, 71
 Buckthorn, Glossy, 112
 Buffalo-berry, Russet, 17
 Bullsnake, 138
 Bullsnake, *Pituophis catenifer sayi*, Nesting Biology in Alberta, 138
 Bunchberry, 212
 Canadian, 19
 Bunting, 154
 Bush-clover, Hairy, 116
 Round-head, 17, 116
Buto, 94
 Buttercup, Bristly, 19
 Early, 20, 94
 Labrador, 17
Calidris alpina, 275
 pusilla, 274
Calidris pusilla, at Farrier's Cove, Shepody Bay, New Brunswick, Cliff Roosting by Migrant Semipalmated Sandpipers, 274
Callophrys niphon, 108
Caloplaca cerina, 200
 cerina holocarpa, 200
 holocarpa, 201
Calystegia spithamea, 106
 spithamea ssp. *spithamea*, 6, 116
Campanula rotundifolia, 7
 Canada Geese, *Branta canadensis parvipes*, along the Tanana River, Alaska, Nesting Biology of Lesser, 29
 Canada Lynx, *Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in New Brunswick and Nova Scotia, 166
 Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, 247
Canadian Association of Herpetologists / Association Canadienne des Herpetologistes Bulletin, 195, 377
Canadian Field-Naturalist, Advice for Contributors to *The*, 198
Candelariella efflorescens, 200
Canis latrans, 31, 167, 173, 176, 270, 271, 312, 316
 lupus, 31, 49, 76, 172, 173, 176, 202, 222, 232, 273, 316, 324
 lupus arctos, 142
 lupus nubilus, 173
 lycaon, 173
Canis latrans, Nomadic Behavior of an Old and Formerly Territorial Eastern Coyote, 316
Canis latrans, Observed Feeding on Periodical Cicadas, *Magicicada septendecim*, Eastern Coyotes, 271
Canis lupus arctos, in Northeast Greenland, 1978-1998, Reproduction and Mortality of the High Arctic Wolf, 142
Canis lupus, Den Site Selection in the Rocky Mountains, Wolf, 49
Canis lupus, from Ages 2 to 24 Months, Weight Changes in Wild Wolves, 173
Canis lupus, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming, Gray Wolves, 76
Caolaptes auratus, 154
 Canvasback, 24
Carcinus maenas, 342
 Cardinal, 154
 Cardinal à poitrine rose, 155
Carex sp., 199
 backii, 7
 cumulata, 106
 houghtoniana, 106
 merritt-fernaldii, 6, 106
 muehlenbergii var. *muehlenbergii*, 6
 pennsylvanica, 7, 106
 richardsonii, 7
 siccata, 6, 106
 tonsa var. *rugosperma*, 6, 106

- tonsa* var. *tonsa*, 19,106
 Caribou, 199,231,324
 Woodland, 231
 Carrion-flower, Smooth, 18
Castianeira longipalpa, 111
Castilleja coccinea, 8
Castor canadensis, 31,169,173,176,299,308
Castor canadensis, Activities along Camrose Creek, Alberta, within Differing Habitats and Management Intensity Levels, The Density of Beaver, 299
 Catchfly, Sleepy, 18
 Catfish, 304
Catharus sp., 156
 guttatus, 156
 ustulatus, 155
 Catling, P.M., Review by, 281
 Catling, P.M. Small Remnants of the Rice Lake Plains Prove Important ... How Many Do We Need?, 93
 Catling, P.M. The Extent and Floristic Composition of the Rice Lake Plains Based on Remnants, 1
 Catling, P.M. and G. Mitrow. Distribution and History of Naturalized Common Pear, *Pyrus communis*, in Ontario, 57
 Catling, P.M., H. Goulet, and B. Kostiuk. Decline of Two Open Champlain Sea Dune Systems in Eastern Ontario and Their Characteristic and Restricted Plants and Insects, 99
Ceanothus americanus, 6,106
 herbaceus, 7
 Cedar, White, 117
Celastrus scandens, 19
Centaurea diffusa, 346
Cerastium arvense ssp. *arvense*, 19
 fontanum ssp. *vulgare*, 19
Cerceris nitidoides, 110
Certhia americana, 157
Cervus elaphus, 50,179,231
 Cestode, 169
 Cetacean, 340
Cetraria sp., 108,231
 islandica, 200
 Checkerspot, Gorgone, 109
Chen caerulescens caerulescens, 34,129,324
 rossii, 34
Chen caerulescens caerulescens, and Ross's Geese, *Chen rossii*, of Jenny Lind Island, Nunavut, Lesser Snow Geese, 34
Chen rossii, of Jenny Lind Island, Nunavut, Lesser Snow Geese, *Chen caerulescens caerulescens*, and Ross's Geese, 34
 chénaie rouge, 153
 Cheney, 1956-2007, Michael, 91
 Cherry, 212
 Black, 18
 Choke, 16,117
 Fire, 20,117
 Susquehanna Sand, 17
 Chickadee, 154
 Black-capped, 320
 Chickweed, Common Mouse-ear, 19
 Field Mouse-ear, 19
 Chipmunk, Eastern, 73
 Yellow-pine, 347
 Chipmunks, *Tamias striatus*, and Hairy-tailed Mole, *Parascalops breweri*, in Kawartha Highlands Provincial Park, Ontario, Swimming Eastern, 73
Chloealtis conspersa, 109
Chlosyne gorgone, 109
Chordeiles minor, 111
Chortophaga viridifasciata, 109
Chrysothamnus nauseosus, 346
 Cicada, Periodical, 271
 Cicadas, *Magicicada septendecim*, Eastern Coyotes, *Canis latrans*, Observed Feeding on Periodical, 271
Cicindela sp., 110
 formosa generosa, 109
 lepida, 109
 punctulata punctulata, 109
 scutellaris lecontei, 109
 tranquebarica, 109
 Cinquefoil, Oldfield, 17
 Tall, 16,117
Circaea lutetiana ssp. *lutetiana*, 19
Cirsium discolor, 7,106
Cladina sp., 108,231
 rangiferina, 108
Cladonia chlorophaea, 200
 gracilis sp. *elongata*, 200
 Clark, H.O., Jr., Review by, 358
 Clark, R.G., 21
Clethrionomys gapperi, 120
 Cloudberry, 324
 Clover, Running Buffalo, 8
 Club-Moss, Common, 116
 Flat-branched Tree, 116
 One-Cone, 116
 Prickly Tree, 116
Coccothraustes vespertinus, 155
Coenonympha tullia inornata, 108
Colaptes auratus, 156
 Colibri à gorge rubis, 154
Colletes inaequalis, 111
 Columbine, Red, 17
Comandra umbellata, 6
 umbellata ssp. *umbellata*, 17
 Comeau, D., 118
Comptonia peregrina, 6
Condylura cristata, 74
Connocheates spp., 81
 Cook, F.R., Reviews by, 84,85,357
Copablepharon longipenne, 101
 Corneille d'amérique, 154
Cornus alternifolia, 19,214
 canadensis, 19,212
 foemina, 19
 racemosa, 17
 rugosa, 17
 sericea, 19
 stolonifera, 19,212
 suecica, 214
Corvus brachyrhynchos, 154
 corax, 268
 corvus, 32
Corylus americana, 7,106
 cornuta, 212
 cornuta var. *cornuta*, 18,116
 Cottonwood, 30
 Eastern, 19
 Cougar, 76
 Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming, Gray Wolves, *Canis lupus*, Killed by, 76

- Cow-wheat, American, 18
 Cowbird, Brown-headed, 26
 Coyote, 31,173,176,270,312
 Eastern, 167,271,316
 Coyote, *Canis latrans*, Nomadic Behavior of an Old and Formerly Territorial Eastern, 316
 Coyotes, *Canis latrans*, Observed Feeding on Periodical Cicadas, *Magicicada septendecim*, Eastern, 271
 Crab, European Green, 342
 Cranberry, Low-bush, 212
 Crane's-bill, Spotted, 19
 Crappie, 303
Crataegus sp., 212
 douglasii var. *douglasii*, 17
 macrantha, 19
 Creeper, 154
 Cricket, Common, 110
 Fourspotted Tree, 110
 Snowy Tree, 110
 Cudweed, Marsh, 19
 Cunner, 247,340
 Cureall, King's, 20
 Currant, 212
 Fetid, 212
 Custer, C.M., 312
 Custer, T.W., 312
Cyanocitta cristata, 154
Cyclotelus rufiventris, 111
Cyperus houghtonii, 106
 lupulinus, 8
 lupulinus ssp. *lupulinus*, 6
Cypripedium parviflorum var. *pubescens*, 19
Cyrtopogon falto, 111

Danaus plexippus, 108
 Dandelion, Common, 67
 Dandelion, *Taraxacum officinale*, in Denali National Park and Preserve, Alaska, Evidence for Higher Soil Temperature and Potassium Promoting Invasion of the Common, 67
Danthonia spicata, 16,106
 Darter, 310
 Eastern Sand, 239
 Darter, *Ammocrypta pellucida*, in Two Lake Champlain Tributaries, Habitat Use by the Eastern Sand, 239
 Deathcamas, Mountain, 20
 Deer, 271
 Black-tailed, 224
 Mule, 50,179,205,231
 Red, 179
 White-tailed, 50,60,173,179,206,221,230,253,273
 Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central Alberta, Rumen Papillae Morphology of Mule, 179
 Deer, *Odocoileus hemionus*, in Central Interior British Columbia, Late-Winter Habitat Use by Mule, 205
 Deer, *Odocoileus virginianus*, Body Fat in Northeastern Minnesota, 1974-1990, Comparisons and Trends in White-tailed, 253
 Deer, *Odocoileus virginianus*, from East-central Alberta, Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed, 179
 Deer, *Odocoileus virginianus*, in Northeastern Alberta, Evidence of Arboreal Lichen Use in Peatlands by White-tailed, 230
 Deer, *Odocoileus virginianus*, Precision of Descriptors for Percent Marrow Fat Content for White-tailed, 273
 Deer, *Odocoileus virginianus*, Spatial Interactions of Yarded White-tailed, 221
Dendroctonus ponderosae, 205
Dendroica caerulescens, 156
 castanea, 155
 fusca, 155
 magnolia, 155
 pensylvanica, 156
 petechia, 156
 pinus, 111
 striata, 155
 tigrina, 155
 virens, 156
 Descamps, S., 65
Deschampsia flexuosa var. *flexuosa*, 19
Desmodium canadense, 7,106
 glutinosum, 7
 nudiflorum, 20
 paniculatum var. *paniculatum*, 7
 Densmore, R.V. Evidence for Higher Soil Temperature and Potassium Promoting Invasion of the Common Dandelion, *Taraxacum officinale*, in Denali National Park and Preserve, Alaska, 67
 Devink, J.-M., 21
 Dewberry, Whiplash, 19
 Dezhi, L. and Q. Aili, Reviews by, 85,86,88,187,283,361
 Dezhi, L., Review by, 87
Dichanthelium acuminatum var. *acuminatum*, 6
 acuminatum var. *fasciculatum*, 106
 columbianum, 6
 depauperatum, 6,106
 implicatum, 6
 latifolium, 7
 linearifolium, 6
 oligosanthes, 12
 oligosanthes var. *scribnerianum*, 20
 perlongum, 7
 sabulorum, 8
 sabulorum var. *thinium*, 6
 villosissimum, 7
 villosissimum var. *praecocius*, 17
 xanthophysum, 6
Dicranum elongatum, 200
Dictophyma renale, 162
Dictophyma renale, Prevalence in Minnesota Mink, *Mustela vison*, Spatial and Temporal Differences in Giant Kidney Worm, 162
Diervilla lonicera, 18
Diphasiastrum complanatum, 116
 digitatum, 106
 tristachyum, 106
Diploplectron peglowi, 110
Dipodomys ordii, 99
Dissosteira carolina, 109
Doellingeria umbellata var. *umbellata*, 20
 Dog, African Wild, 146
 Dogbane, Spreading, 16,116
 Dogwood, Alternate-leaf, 19
 Gray, 17
 Red-osier, 212
 Round-leaf, 17
 Stiff, 19
 Dolphin, Atlantic White-sided, 262

- White-beaked, 262
- Dolphin *Lagenorhynchus albirostris*, with a Gunshot Wound as a Possible Cause, First Record of a Collapsed Dorsal Fin in a White-beaked, 262
- Douglas-fir, 52,205
- Drepanocladus uncinatus*, 200
- Dropseed, Sand, 18,117
- Drosera rotundifolia*, 108
- Dryas integrifolia*, 199
- Dryocopus martius*, 229
- pileatus*, 226
- Dryocopus pileatus*, Foraging in Suburban Habitats in New Brunswick, Pileated Woodpeckers, 226
- Dulude, J., 274
- Dunbrack, R. Abundance Trends for *Hexanchus griseus*, Bluntnose Sixgill Shark, and *Hydrolagus collieri*, Spotted Ratfish, Counted at an Automated Underwater Observation Station in the Strait of Georgia, British Columbia, 124
- Dunlin, 275
- Dytiscus alaskanus*, 78
- Eagle, Bald, 31
- Golden, 268
- Eagle, *Aquila chrysaetos*, Nest, Egg Predation at a Golden, 268
- Editor's Report for Volume 121 (2007), 196
- Eelgrass, 338
- Elaphe obsoleta*, 73
- Elder, Black, 20
- Red-berried, 212
- Elfin, Eastern Pine, 108
- Elk, 50,180,231
- Elm, 226
- Ely, C.R., J.M. Pearce and R.W. Ruess. Nesting Biology of Lesser Canada Geese, *Branta canadensis parvipes*, along the Tanana River, Alaska, 29
- Elymus* sp., 67
- canadensis*, 19
- trachycaulus* ssp. *subsecundus*, 16
- unilaterale*, 16
- Empetrum atropurpureum*, 214
- eamesii*, 214
- nigrum*, 214
- Empidonax oberholseri*, 268
- Emydoidea blandingii*, 61
- Emydoidea blandingii*, in Central Wisconsin, Annual vs. Multiple-Year Home Range Sizes of Individual Blanding's Turtles, 61
- Enchanter's-nightshade, Broad-leaf, 19
- Epigaea repens*, 20
- Equisetum hyemale*, 116
- hyemale* var. *affine*, 18
- hyemale* × *variegatum*, 20
- × *mackaii*, 20
- variegatum*, 106
- érable à sucre, 153
- Erethizon dorsatum*, 45,264
- Erethizon dorsatum*, in Wisconsin, Use of Winter Dens by Porcupines, 45
- Erethizon dorsatum*, Winter Den-sites in Living Trees in Wisconsin, Characteristics of Porcupine, 264
- Erigeron pulchellus*, 8
- pulchellus* var. *pulchellus*, 18
- strigosus*, 18
- Errata *Canadian Field-Naturalist* 121(4), 290
- Errata *Canadian Field-Naturalist* 122(2), 290
- Errata *The Canadian Field-Naturalist* 121(1): 96, 195
- Errata *The Canadian Field-Naturalist* 122(1): 40, 195
- Erskine, A.J. Pileated Woodpeckers, *Dryocopus pileatus*, Foraging in Suburban Habitats in New Brunswick, 226
- Etheostoma* sp., 310
- Etourneau sansonnet, 154
- Eupatorium maculatum* var. *maculatum*, 19
- Eurybia macrophylla*, 18
- Euthamia graminifolia* var. *graminifolia*, 18
- Euxoa albipennis*, 109
- auxiliaris*, 272
- detersa*, 109
- quebecensis*, 109
- scandens*, 109
- Evening-primrose, Small, 20
- Evernia mesomorpha*, 200
- Exoprosopa fascipennis*, 111
- Facey, D.E., 239
- Fagus grandifolia*, 153
- Falco peregrinus*, 274
- Falcon, Peregrine, 274
- Farewell-summer, 19
- Fast, M., R.G. Clark, R.W. Brook, P.L.F. Fast, J.-M. Devink, and S.W. Leach. Eye Colour, Aging, and Decoy Trap Bias in Lesser Scaup, *Aythya affinis*, 21
- Fast, P.L.F., 21
- Fern, Cut-Leaf Grape, 8
- Leathery Grape, 19
- Northern Bracken, 16
- Fescue, Six-weeks, 346
- Feverwort, 20
- Figwort, Lance-leaf, 20
- Fir, Balsam, 118,169,213,231
- Grand, 52
- Subalpine, 206
- Fisher, 269
- Fisher, *Martes pennanti*, in Quebec, Differential Footload of Male and Female, 269
- Flavocetraria nivalis*, 200
- Flax, Grooved Yellow, 18
- Fleabane, Prairie, 18
- Flounder, Winter, 340
- Fly-honeysuckle, American, 20
- Flycatcher, Dusky, 268
- Fortin, C. and D. Comeau. Habitat Parameters and Small Mammal Associations of the Gaspé Shrew, *Sorex gaspensis*, in the Eastern Gaspé Peninsula, Québec, 118
- Fox, Bat-eared, 271
- Grey, 169
- Red, 31,167,270,271,320
- Fox, *Urocyon cinereoargenteus*, in New Brunswick: a Climate-change Mediated Range Expansion?, First Occurrence of the Grey, 169
- Foxglove, Slender-Leaf False, 106
- Fragaria americana*, 212
- virginiana*, 106,214
- virginiana* ssp. *virginiana*, 8,116
- Frangula alnus*, 112
- Fraser, E.E. and J.F. Miller. Diurnal Above-ground Movement in Hairy-tailed Moles, *Parascalops breweri*, 267

- Fraxinus* spp., 153
 frêne, 153
 Frog, Boreal Chorus, 130, 158
 Western Chorus, 158
 Wood, 130, 160
 Frog, *Pseudacris triseriata*, in Eastern Ontario, A Localized Decline in the Western Chorus, 158
 Frostweed, Hoary, 18
 Long-branch, 18
Fundulus diaphonus diaphonus, 342
 heteroclitus, 342

Galium circaezans, 18
Gambusia affinis, 304
Gasterosteus aculeatus, 340
Gaultheria procumbens, 20, 116
Gavia immer, 70, 268
Gavia immer, Nocturnal Behavior of the Common Loon, 70
 Gayfeather, Ontario, 18
Gaylussacia baccata, 20
 Gaywings, 19
 Geai bleu, 154
 Geese, *Branta canadensis parvipes*, along the Tanana River, Alaska, Nesting Biology of Lesser Canada, 29
 Geese, *Chen caerulescens caerulescens*, and Ross's Geese, *Chen rossii*, of Jenny Lind Island, Nunavut, Lesser Snow, 34
 Geese, *Chen rossii*, of Jenny Lind Island, Nunavut, Lesser Snow Geese, *Chen caerulescens caerulescens*, and Ross's, 34
 Gem, Gold-edged, 101
 Gentian, Closed Bottle, 20
 Greater Fringed, 106
Gentiana andrewsii var. *andrewsii*, 20
 quinquefolia, 8
Gentianella quinquefolia, 8
Gentianopsis crinita, 106
Geothlypis trichas, 156
Geranium maculatum, 19
Geum aleppicum, 20
 canadense var. *canadense*, 20
 triflorum, 94
 triflorum var. *triflorum*, 20
 Gilhen, J. and K. Aaboe. Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, 247
Gnaphalium obtusifolium, 19
Gnaphosa parvula, 111
 Goldenrod, Atlantic, 19
 Canadian, 17
 Early, 16, 117
 Gray, 16, 117
 Hairy, 20
 Late, 18
 White, 18
 Wrinkle-leaf, 19
 Goldentop, Flat-top, 18
 Goodwin, C.E., Review by, 184
 Goose, Cackling, 36
 Canada, 29, 134
 Canada, 324
 Lesser Canada, 29
 Lesser Snow, 34, 129, 324
 Red-breasted, 32
 Richardson's Cackling, 29
 Ross's, 34
 Taverner's Cackling, 29
 Gorelick, R. and S.M. Bertram. Swimming Eastern Chipmunks, *Tamias striatus*, and Hairy-tailed Mole, *Parascalops breweri*, in Kawartha Highlands Provincial Park, Ontario, 73
 Gormezano, L., 323
 Goulet, H., 99
 Grackle, 154
 Grape, River-bank, 16, 117
 Summer, 20
 Grass, Broad-leaf Rosette, 18
 Brome, 99
 Elongate Panic, 18
 False Melic, 18
 Flat-stem Blue, 105
 Heller's Rosette, 20
 Hemlock Rosette, 18
 Kentucky Blue, 16, 116
 Philadelphia Panic, 20
 Poverty Wild Oat, 16, 116
 Quack, 346
 Slender Rosette, 18
 Slim-leaf Rosette, 18
 Smooth Brome, 8
 Starved Rosette, 18, 116
 Tapered Rosette, 17, 116
 Vanilla, 20
 Wand Panic, 19, 116
 Wavy Hair, 19
 White-grain Mountain-rice, 19, 116
 Yellow Indian, 16
 Grasshopper, Boll's, 109
 Carolina, 109
 Greenstriped, 109
 Keeler's, 109
 Migratory, 109
 Mottled Sand, 109
 Pinetree Spurthroat, 109
 Redlegged, 109
 Sprinkled Broad-winged, 109
 Greenland, 1978-1998, Reproduction and Mortality of the High Arctic Wolf, *Canis lupus arctos*, in Northeast, 142
 Grimpereau brun, 157
 Grimpereaux, 154
Grindelia squarrosa var. *squarrosa*, 6
 Grive, 154
 à dos olive, 155
 des bois, 156
 solitaire, 156
 Grooveburr, Tall Hairy, 18
 Gros-bec, 154
 errant, 155
 Grosbeak, 154
 Ground-Cedar, Blue, 116
 Ground-cherry, Clammy, 18, 116
 Ground-pine, Deep-root, 20
 Trailing, 20
 Groundsel, Balsam, 20
 Grouse, Ruffed, 169
 Grouseberry, 52

- Gryllus pennsylvanicus*, 110
 Guiasu, R.C., Review by, 89
 Gull, Glaucous, 32
 Mew, 32
Gulo gulo, 270
 Gumweed, Curly-cup, 19
- Hainault, 1940 - 2008, A Tribute to Robert, 95
 Hake, White, 340
Haliaeetus leucocephalus, 31
Hamamelis virginiana, 19
 Hamilton, D.A., 303
 Hare, Snowshoe, 168
 Varying, 169
Harpalus caliginosus, 109
 compar, 109
 erraticus, 109
 fuscipalpis, 109
 herbivagus, 109
 lewisi, 109
 opacipennis, 109
 plennis, 109
 Hawkweed, Canadian, 20
 Tall, 116
 Hawthorn, 19,212
 Black, 17
 Hazelnut, American, 18,116
 Beaked, 18,116,212
 Hébert, R., C. Samson and J. Huot. Factors Influencing the Abundance of Berry Plants for Black Bears, *Ursus americanus*, in Quebec, 212
Hedeoma hispida, 113
 Hedman, D., 323
Hedysarum alpinum, 67
Helianthemum bicknellii, 6
 canadense, 6
Helianthus divaricatus, 6,106
 strumosus, 7,106
 Herb, Woodland, 234
 Herb, *Maianthemum canadense* (Liliaceae), Effects of Forest Cover on Fruit Set in the Woodland, 234
 Heron, Great Blue, 73
Hesperia leonardus, 108
Heterodon, 94
 hêtraie, 153
Hexanchus griseus, 124
Hexanchus griseus, Bluntnose Sixgill Shark, and *Hydrolagus coliei*, Spotted Ratfish, Counted at an Automated Underwater Observation Station in the Strait of Georgia, British Columbia, Abundance Trends for, 124
 Hicklin, P.W., 274
Hieracium canadense var. *divaricatum*, 20
 piloselloides, 106
Hierchloe odorata, 20
 Higdon, J.W. and D. Snow. First Record of a Collapsed Dorsal Fin in a White-beaked Dolphin *Lagenorhynchus albirostris*, with a Gunshot Wound as a Possible Cause, 262
 Hines, J.E., 34
 Hirondelle bicolore, 154
 Hog-peanut, American, 18
 Honeysuckle, Hairy, 19
 Limber, 18
 Northern Bush, 18
 Hooper, R.G., 338
 Houston, C.S., Reviews by, 286,288,370,371
 Huckleberry, Black, 20
 Mountain, 52
 Hudson, R.J., 179
 Huettmann, F., Reviews by, 186,188,191,359,362,365,367
 Huot, J., 212
 Hvenegaard, G.T., 299
Hydrolagus coliei, 124
Hydrolagus coliei, Spotted Ratfish, Counted at an Automated Underwater Observation Station in the Strait of Georgia, British Columbia, Abundance Trends for *Hexanchus griseus*, Bluntnose Sixgill Shark, and, 124
Hyla versicolor, 160
Hylocichla mustelina, 156
Hypericum ascyron, 8
 pyramidatum, 8
Hypogymnia physodes, 200
- Idris* sp., 110
 Indian-Paintbrush, Scarlet, 8
 Indian-pipe, Many-flower, 19
 One-flower, 20
Isistius brasiliensis, 263
 Ivy, Poison, 16
- Jaseur d'amérique, 154
 Jimenez, M.D., V.J. Asher, C. Bergman, E.E. Bangs and S.P. Woodruff. Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming, 76
 Joe-pye-weed, Spotted, 19
 John, R., Reviews by, 83,84,182,183
 Johnson, K.M., 312
 Jointweed, Coastal, 117
 Jones, J.D. and J.J. Treanor. Allonursing and Cooperative Birthing Behavior in Yellowstone Bison, *Bison bison*, 171
Junco hyemalis, 155
 Junco, 154
 Junco ardoisé, 155
Juncus greenei, 108
 Juneberry, 1
 Juniper, Common, 17,52,116
Juniperus communis, 6,52,106
 communis var. *depressa*, 17,116
 virginiana var. *virginiana*, 6
- Kay, D.G., 34
 Kennedy, A.C., 166,274
 Kerbes, R.H., K.M. Meeres, J.E. Hines and D.G. Kay. Lesser Snow Geese, *Chen caerulescens caerulescens*, and Ross's Geese, *Chen rossii*, of Jenny Lind Island, Nunavut, 34
 Kerr, K.C.R. Dytiscid Beetle Remains Discovered in a Pellet from a Great Gray Owl, *Strix nebulosa*, Nest, 78
 Kerr, T. and S. Descamps. Why do North American Red Squirrel, *Tamiasciurus hudsonicus*, Mothers Relocate Their Young? A Predation-based Hypothesis, 65
 Kevan, P.G., 234
 Killifish, 304
 Eastern Banded, 342
 Kinglet, 154
 Knapweed, Diffuse, 346
 Knotweed, Douglas', 19
 Kostiuk, B., 99

- Kuzyk, G.W. and R.J. Hudson. Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central Alberta, 179
- Lactuca canadensis*, 20
 hirsuta, 8
 serriola, 346
- Ladies-tresses, Case's, 20
 Nodding, 106
 Northern Slender, 20
- Lady's Slipper, Lesser Yellow, 19
- Lagenorhynchus acutus*, 262
 albirostris, 262
- Lagenorhynchus albirostris*, with a Gunshot Wound as a Possible Cause, First Record of a Collapsed Dorsal Fin in a White-beaked Dolphin, 262
- Lampetra ayresii*, 327
 fluviatilis, 327
 folletti, 328
 hubbsi, 328
 lethophaga, 328
 macrostoma, 327
 minima, 328
 planeri, 327
 richardsoni, 327
 similis, 328
 tridentata, 327
- Lampetra macrostoma*, Critical Habitat and the Conservation Ecology of the Freshwater Parasitic Lamprey, 327
- Lamprey, 327
 Cowichan, 327
- Lamprey, *Lampetra macrostoma*, Critical Habitat and the Conservation Ecology of the Freshwater Parasitic, 327
- Lance, Sand, 340
- Larch, Western, 52
- Larivière, S., 269
- Larix laricina*, 176, 199, 231
 occidentalis, 52
- Larsen, B.N., 80
- Larus canus*, 32
 hyperboreus, 32
- Lasioglossum vierecki*, 111
- Latham, A.D.M. Evidence of Raccoon, *Procyon lotor*, Range Extension in Northern Alberta, 176
- Latham, A.D.M. and S. Boutin. Evidence of Arboreal Lichen Use in Peatlands by White-tailed Deer, *Odocoileus virginianus*, in Northeastern Alberta, 230
- Lathyrus ochroleucus*, 19
- Lauff, R., Reviews by, 184, 359, 371
- Laurel, California Bay, 80
- Lavoie, M., 269
- Leach, S.W., 21
- Lecanora circumborealis*, 200
 symmicta, 200
- Lechea intermedia* var. *intermedia*, 6
- Lecidella euphorea*, 200
- Legume, 67
- Lemming, Southern Bog, 120
- Lepomis* sp., 303
- Lepus americanus*, 168, 169
- Lespedeza capitata*, 7, 106
 hirta, 106
 hirta ssp. *hirta*, 116
- Lettuce, Florida Blue, 20
 Hairy, 8
 Prickly, 346
- Liatris cylindracea*, 6
- Libby, C., 169
- Library of the Swiss Orchid Foundation at the Herbarium Jany Renz, The, 91
- Lichen, 231
- Lilium philadelphicum* var. *philadelphicum*, 6
- Lily-of-the-valley, False, 17, 116
- Lily, Wood, 17
- Lim, B.K., Review by, 284
- Linden, 228
- Linum sulcatum*, 8
 sulcatum var. *sulcatum*, 6
- Lithobates sylvaticus*, 130, 160
- Littorina littorea*, 250
- Livingston, John Allen, 194
- Loates, B.M. and G.T. Hvenegaard. The Density of Beaver, *Castor canadensis*, Activities along Camrose Creek, Alberta, within Differing Habitats and Management Intensity Levels, 299
- Locoweed, Field, 67
- Lonicera canadensis*, 20
 dioica, 18
 hirsuta, 19
- Lontra canadensis*, 247, 303
- Lontra canadensis*, Food Habits in the Missouri Ozarks, River Otter, 303
- Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, Winter Predation by River Otter, 247
- Loon, Common, 70, 268
- Loon, *Gavia immer*, Nocturnal Behavior of the Common, 70
- Lousewort, Canadian, 19
- Lumbriculus variegatus*, 164
- Lupine, Sundial, 18
- Lupinus perennis*, 8
 perennis ssp. *perennis* var. *perennis*, 7
- Lutra lutra*, 304
- Luzula acuminata*, 7
 acuminata var. *acuminata*, 19
- Lycaon pictus*, 146
- Lycopodium clavatum*, 116
 complanatum, 20
 dendroideum, 116
 digitatum × *tristachyum*, 20
 × *habereri*, 20
 lagopus, 116
 obscurum, 116
 tristachyum, 20
- Lynx canadensis*, 166, 269
 rufus, 167
- Lynx, Canada, 166, 269
- Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in New Brunswick and Nova Scotia, Canada Lynx, 166
- Lynx, *Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in New Brunswick and Nova Scotia, Canada, 166
- Lysimachia quadriflora*, 20

- Mack, C., 49
 Mackerel, Atlantic, 340
 MacKinnon, C.M. and A.C. Kennedy. Canada Lynx, *Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in New Brunswick and Nova Scotia, 166
 MacKinnon, C.M., J. Dulude, A.C. Kennedy, S.J.E. Surette and P.W. Hicklin. Cliff Roosting by Migrant Semipalmated Sandpipers, *Calidris pusilla*, at Farrier's Cove, Shepody Bay, New Brunswick, 274
Maginicada septendecim, 271
tredicassini, 271
Maginicada septendecim, Eastern Coyotes, *Canis latrans*, Observed Feeding on Periodical Cicadas, 271
Maianthemum canadense, 17,106,234
racemosum ssp. *racemosum*, 17
stellatum, 8,116
Maianthemum canadense (Liliaceae), Effects of Forest Cover on Fruit Set in the Woodland Herb, 234
 Maiden's-Tears, 117
Malaxis unifolia, 20
 Manitoba, Anurans in a Subarctic Tundra Landscape Near Cape Churchill, 129
 Manitoba, A Survey of Lichens and Bryophytes in White Spruce, *Picea glauca*, Tree Islands on a Calcareous Beach Ridge in Northeastern, 199
 Manitoba, Grizzly Bears, *Ursus arctos*, in Wapusk National Park, Northeastern, 323
 Maple, 226
 Manitoba, 228
 Mountain, 19,118
 Norway, 226
 Red, 19,228
 Silver, 228
 Sugar, 18,118,213,228
Marine Turtle Newsletter, 91,194,290,377
 Marquard-Petersen, U. Reproduction and Mortality of the High Arctic Wolf, *Canis lupus arctos*, in Northeast Greenland, 1978-1998, 142
 Marten, American, 31,270
Martes americana, 32,270
pennanti, 269
Martes pennanti, in Quebec, Differential Footload of Male and Female Fisher, 269
 Martin, J.D., 169
 May-apple, 19
 Mayflower, Canada, 234
 Maystar, 20
 Mcalpine, D., J.D. Martin and C. Libby. First Occurrence of the Grey Fox, *Urocyon cinereoargenteus*, in New Brunswick: a Climate-change Mediated Range Expansion?, 169
 McBride, B., Review by, 185
 McCarthy, J., Reviews by, 279,280
 McKenzie, C.H., 338
 Meadow-rue, Early, 18
 Mech, L.D. Precision of Descriptors for Percent Marrow Fat Content for White-tailed Deer, *Odocoileus virginianus*, 273
 Mech, L.D. Spatial and Temporal Differences in Giant Kidney Worm, *Dictophyma renale*, Prevalence in Minnesota Mink, *Mustela vison*, 162
 Mech, L.D. Weight Changes in Wild Wolves, *Canis lupus*, from Ages 2 to 24 Months, 173
Medicago sylvatica, 346
 Meeres, K.M., 34
Melampyrum lineare var. *lineare*, 18
Melanelia exasperatula, 200
septentrionalis, 200
Melanoplus femurrubrum, 109
keeleri luridus, 109
punctulatus punctulatus, 109
sanguinipes sanguinipes, 109
Melitaea gorgone, 109
Melospiza melodia, 157
Menidia beryllina, 338
menidia, 338
Menidia menidia, to Coastal Waters of Southwestern Newfoundland, A Range Extension of the Atlantic Silverside, 338
Mephitis mephitis, 80
Mephitis mephitis, A Group Defense Incident Involving Juvenile Striped Skunks, 80
 Merle d'amérique, 154
 Mésange à tête noire, 154
 Methven, D.A., 338
 Mice, *Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in Southern British Columbia, Dynamics of Peripheral Populations of Great Basin Pocket, 345
 Mice, *Reithrodontomys megalotis*, in Southern British Columbia, Dynamics of Peripheral Populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest, 345
Microbembix monodonta, 110
Microgadus tomcod, 340
Micropterus sp., 303
Microtus sp., 346
chrotorrhinus, 121
longicaudus, 347
montanus, 347
pennsylvanicus, 120
 Milkweed, Butterfly, 1
 Common, 16,116
 Poke, 18
 Milkwort, Purple, 106
 Racemed, 17
 Whorled, 108
 Miller, J.F., 267
 Mink, 162
 Mink, *Mustela vison*, Spatial and Temporal Differences in Giant Kidney Worm, *Dictophyma renale*, Prevalence in Minnesota, 162
 Minnesota Mink, *Mustela vison*, Spatial and Temporal Differences in Giant Kidney Worm, *Dictophyma renale*, Prevalence in, 162
 Minnesota, 1974-1990, Comparisons and Trends in White-tailed Deer, *Odocoileus virginianus*, Body Fat in Northeastern, 253
 Mint, Virginia Mountain, 8
 Minutes of the 129th Annual Business Meeting of the Ottawa Field-Naturalists' Club 15 January 2008, 291
Miscophus americanus, 110
 Missouri Ozarks, River Otter, *Lontra canadensis*, Food Habits in the, 303
 Mitrow, G., 57
 Moccasin, Water, 73
 Moineau domestique, 154
 Mole, Eastern, 74
 Hairy-tailed, 73,267

- Star-nosed, 74
Townsend's, 267
- Mole, *Parascalops breweri*, in Kawartha Highlands Provincial Park, Ontario, Swimming Eastern Chipmunks, *Tamias striatus*, and Hairy-tailed, 73
- Molothrus ater*, 26
- Monarch, 108,
- Monarda fistulosa*, 8,106
fistulosa ssp. *fistulosa*, 116
fistulosa ssp. *fistulosa* var. *fistulosa*, 6
punctata, 113
Monotropa hypopithys, 19
uniflora, 20
- Montana, Alberta, and Wyoming, Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in, 76
- Moose, 50,77,173,179,231,273,324
- Morton, M.L. and M.E. Pereyra. Egg Predation at a Golden Eagle, *Aquila chrysaetos*, Nest, 268
- Mosquitofish, Western, 304
- Moth, Army Cutworm, 272
Dusky Dune, 101
White Flower, 101
- Mountain-Mint, Virginia, 117
- Mouse, Deer, 347
Great Basin Pocket, 345
House, 347
Western Harvest, 345
Woodland Jumping, 120
- Muhlenbergia glomerata*, 7
mexicana, 18,116
- Muhly, Mexican, 18,116
Spiked, 18
- Mullein, Great, 346
- Mummichog, 342
- Munroe, Eugene Gordon, 195
- Mus musculus*, 347
- Musko, 146
- Muskrat, 73,308
- Mussel, Blue, 250
Horse, 250
- Mustard, Tower, 19
- Mustela erminea*, 347
vison, 162
- Mustela vison*, Spatial and Temporal Differences in Giant Kidney Worm, *Dictophyma renale*, Prevalence in Minnesota Mink, 162
- Myiarchus crinitus*, 154
- Myoxocephalus* sp., 340
- Myrmeleon immaculatus*, 111
- Mytilus* sp., 250
- Nanny-berry, 19
- Napaeozapus insignis*, 121
- Natzke, L.L. and R.P. Thiel. Characteristics of Porcupine, *Erethizon dorsatum*, Winter Den-sites in Living Trees in Wisconsin, 264
- Nelson, M.E. and G.A. Sargeant. Spatial Interactions of Yarded White-tailed Deer, *Odocoileus virginianus*, 221
- Nerodia sipedon*, 73
- New Brunswick: a Climate-change Mediated Range Expansion?, First Occurrence of the Grey Fox, *Urocyon cinereoargenteus*, in, 169
- New Brunswick and Nova Scotia, Canada Lynx, *Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in, 166
- New Brunswick, Cliff Roosting by Migrant Semipalmated Sandpipers, *Calidris pusilla*, at Farrier's Cove, Shepody Bay, 274
- New Brunswick, Pileated Woodpeckers, *Dryocopus pileatus*, Foraging in Suburban Habitats in, 226
- New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and, 247
- New Jersey-tea, 16,116
- Newfoundland, A Range Extension of the Atlantic Silverside, *Menidia menidia*, to Coastal Waters of Southwestern, 338
- Nicholson, K.L., W.J. Peterson and W.B. Ballard. Comparisons and Trends in White-tailed Deer, *Odocoileus virginianus*, Body Fat in Northeastern Minnesota, 1974-1990, 253
- Nightcaps, 19
- Nighthawk, Common, 111
- North Dakota, Contaminant Levels in Eggs of American White Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, 312
- Nova Scotia and New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in, 247
- Nova Scotia, Canada Lynx, *Lynx canadensis*, Use of the Chignecto Isthmus and the Possibility of Gene Flow between Populations in New Brunswick and, 166
- Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, 247
- Nunavut, Lesser Snow Geese, *Chen caerulescens caerulescens*, and Ross's Geese, *Chen rossii*, of Jenny Lind Island, 34
- Nut, Hazel, 1
- Oak, 61,73,265
Black, 13,265
Coast Live, 80
Northern Red, 16,117
Northern White, 17
Red, 265
White, 265
- O'Brien, S.M. and D.E. Facey. Habitat Use by the Eastern Sand Darter, *Ammocrypta pellucida*, in Two Lake Champlain Tributaries, 239
- Ochrolechia androgyna*, 200
frigida, 200
- Odocoileus* sp., 205,271
hemionus, 50,179,205,231
hemionus columbianus, 224
virginianus, 50,60,173,179,206,221,230,253,273
- Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central Alberta, Rumen Papillae Morphology of Mule Deer, 179
- Odocoileus hemionus*, in Central Interior British Columbia, Late-Winter Habitat Use by Mule Deer, 205

- Odocoileus virginianus*, Body Fat in Northeastern Minnesota, 1974-1990, Comparisons and Trends in White-tailed Deer, 253
- Odocoileus virginianus*, from East-central Alberta, Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, 179
- Odocoileus virginianus*, in Northeastern Alberta, Evidence of Arboreal Lichen Use in Peatlands by White-tailed Deer, 230
- Odocoileus virginianus*, Precision of Descriptors for Percent Marrow Fat Content for White-tailed Deer, 273
- Odocoileus virginianus*, Spatial Interactions of Yarded White-tailed Deer, 221
- Oecanthus fultoni*, 110
- quadripunctatus*, 110
- Oenothera biennis*, 20
- perennis*, 20
- Old-man's-whiskers, 20
- Oncorhynchus clarki*, 332
- kisutch*, 329
- mykiss*, 43
- Ondatra zibethica*, 73
- zibethicus*, 308
- Ontario, A Localized Decline in the Western Chorus Frog, *Pseudacris triseriata*, in Eastern, 158
- Ontario and Their Characteristic and Restricted Plants and Insects, Decline of Two Open Champlain Sea Dune Systems in Eastern, 99
- Ontario, Distribution and History of Naturalized Common Pear, *Pyrus communis*, in, 57
- Ontario, Swimming Eastern Chipmunks, *Tamias striatus*, and Hairy-tailed Mole, *Parascalops breweri*, in Kawartha Highlands Provincial Park, 73
- Oporornis philadelphia*, 155
- Orchid, Green Adder's-mouth, 20
- Orcinus orca*, 263
- Orconectes luteus*, 310
- punctimanus*, 310
- Oregon-grape, Creeping, 52
- Orobanche uniflora*, 20
- Orthilia secunda*, 20
- Orthotrichum speciosum*, 200
- Oryzopsis asperifolia*, 7,106
- Osmerus mordax*, 340
- Oswego, 16
- Oswego-Tea, 116
- Otocyon megalotis*, 271
- Ottawa Field-Naturalists' Club Awards for 2007, The, 379
- Otter, European River, 304
- River, 247,303
- Otter, *Lontra canadensis*, Food Habits in the Missouri Ozarks, River, 303
- Otter, *Lontra canadensis*, on Tautog, *Tautog onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, Winter Predation by River, 247
- Ovibos moschatus*, 81,146
- Owl, Great Gray, 78
- Great-horned, 71
- Owl, *Strix nebulosa*, Nest, Dytiscid Beetle Remains Discovered in a Pellet from a Great Gray, 78
- Ox, Musk, 81
- Oxytropis campestris*, 67
- Packera paupercula*, 20
- Panicum philadelphicum*, 20
- virgatum*, 106
- virgatum* var. *virgatum*, 6
- Paquet, P.C., 49
- Parascalops breweri*, 73,267
- Parascalops breweri*, in Kawartha Highlands Provincial Park, Ontario, Swimming Eastern Chipmunks, *Tamias striatus*, and Hairy-tailed Mole, 73
- Parmelia sulcata*, 200
- Parmeliopsis ambigua*, 200
- Parnis, L., Review by, 369
- Parsons, D.R., 49
- Parthenocissus inserta*, 19
- quinquefolia*, 19
- Paruk, J.D. Nocturnal Behavior of the Common Loon, *Gavia immer*, 70
- Parula americana*, 156
- Paruline, 154
- à ailes dorées, 156
- à calotte noire, 155
- à collier, 156
- à croupion jaune, 156
- à flancs marron, 156
- à gorge noire, 156
- à gorge orangée, 155
- à joues grises, 156
- à poitrine baie, 155
- à tête cendrée, 155
- bleue, 156
- couronnée, 155
- des ruisseaux, 156
- du Canada, 155
- jaune, 156
- masquée, 156
- obscur, 155
- rayée, 155
- tête mangée, 156
- tigrée, 155
- Parus atricapillus*, 156,320
- Passer domesticus*, 154
- Pear, Callery, 58
- Common, 57
- Pear, *Pyrus communis*, in Ontario, Distribution and History of Naturalized Common, 57
- Pearce, J.M., 29
- Pearly-everlasting, 17,116
- Pedicularis canadensis* ssp. *canadensis*, 19
- Pelecanus erythrorhynchos*, 312
- Pelecanus erythrorhynchos*, from Chase Lake, North Dakota, Contaminant Levels in Eggs of American White Pelicans, 312
- Pelican, American White, 312
- Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, North Dakota, Contaminant Levels in Eggs of American White, 312
- Penstemon digitalis*, 20
- hirsutus*, 6
- Pereyra, M.E., 268
- Periwinkle, Common, 250
- Perognathus parvus*, 345
- Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in Southern British Columbia, Dynamics of Peripheral Populations of Great Basin Pocket Mice, 345

- Peromyscus* sp., 120
 maniculatus, 347
 Peterson, W.J., 253
Phalaris arundinacea, 108
Pheucticus ludovicianus, 155
Phidippus purpuratus, 111
 Phoebe, Say's, 268
Physalis heterophylla, 18,106
 heterophylla var. *heterophylla*, 116
Physcia adscendens, 200
 aipolia, 200
Physconia muscigena, 200
 Pic, 154
 à dos noir, 156
 chevelu, 157
 flamboyant, 154
Picea sp., 120,199,222,226
 abies, 202
 engelmannii, 52,206
 glauca, 30,106,176,199,206,231
 mariana, 176,199,206,213,231
Picea glauca, Tree Islands on a Calcareous Beach Ridge in Northeastern Manitoba, A Survey of Lichens and Bryophytes in White Spruce, 199
Picoides arcticus, 156
 villosus, 157
 Piercey-Normore, M.D. A Survey of Lichens and Bryophytes in White Spruce, *Picea glauca*, Tree Islands on a Calcareous Beach Ridge in Northeastern Manitoba, 199
 Pietz, P.J., M.A. Sovada, C.M. Custer, T.W. Custer, and K.M. Johnson. Contaminant Levels in Eggs of American White Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, North Dakota, 312
 Pine, Eastern White, 16,116
 Jack, 61,116,222,231
 Limber, 52
 Lodgepole, 52,205
 Ponderosa, 346
 Red, 17,116
 Scots, 99
 White, 265
 Pintail, Northern, 24
Pinus banksiana, 61,106,222,231
 contorta, 52,205
 flexilis, 52
 ponderosa, 346
 resinosa, 6,106
 strobus, 16,106,265
 sylvestris, 99
 Pinweed, Round-fruit, 17
Pituophis catenifer deserticola, 140
 catenifer sayi, 138
 melanoleucus melanoleucus, 139
 spiloides × *alleganiensis*, 73
Pituophis catenifer sayi, Nesting Biology in Alberta, Bull-snake, 138
Plenoculus davisii, 110
Pleurozium schreberi, 200
 Plum, Canadian, 18
Poa compressa, 105
pratensis, 106
pratensis ssp. *pratensis*, 8
Podophyllum peltatum, 19
Poecile atricapillus, 154
Polygala paucifolia, 19
polygala, 6
 sanguinea, 106
 senega, 7
 verticillata, 108
Polygonatum biflorum, 20
Polygonella articulata, 106
Polygonum douglasii, 8
 douglasii ssp. *douglasii*, 6
Polytrichum sp., 106
Pomoxis sp., 303
 Poplar, 30,169
 Balsam, 19,117
Populus sp., 30,61,169,205,265
 balsamifera, 106
 balsamifera ssp. *balsamifera*, 19,117
 deltoides ssp. *deltoides*, 19
 grandidentata, 18,265
 tremuloides, 17,106,173,176,179,205,222,228,231,299
 Porcupine, 45,264
 Porcupine, *Erethizon dorsatum*, Winter Den-sites in Living Trees in Wisconsin, Characteristics of, 264
 Porcupines, *Erethizon dorsatum*, in Wisconsin, Use of Winter Dens by, 45
Potentilla arguta ssp. *arguta*, 6,117
 simplex, 6
 Pouliot, Y. Les collisions d'oiseaux à l'édifice Marly à Sainte-Foy, Québec, de 1978 à 2007, 153
Prenanthes alba, 20
 altissima, 20
Proctacanthus milberti, 111
Procyon lotor, 47,60,176
Procyon lotor, Range Extension in Northern Alberta, Evidence of Raccoon, 176
Protopannaria pezizoides, 200
 Proulx, G. Late-Winter Habitat Use by Mule Deer, *Odocoileus hemionus*, in Central Interior British Columbia, 205
Prunella vulgaris ssp. *vulgaris*, 18
Prunus sp., 212
 nigra, 18
 pensylvanica, 106,214
 pensylvanica var. *pensylvanica*, 20
 pumila var. *susquehanae*, 6
 serotina, 18,214
 virginiana, 106,214
 virginiana var. *virginiana*, 8
Pseudacris maculata, 130,158
 triseriata, 158
Pseudacris triseriata, in Eastern Ontario, A Localized Decline in the Western Chorus Frog, 158
Pseudognaphalium obtusifolium, 117
Pseudopleuronectes americanus, 340
Pseudorca crassidens, 263
Pseudotsuga menziesii, 52,205
Psinidia fenestralis, 113
Pteridium aquilinum, 106
 aquilinum var. *latiusculum*, 8,117
Puma concolor, 76
Puma concolor, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming, Gray Wolves, *Canis lupus*, Killed by Cougars, 76
Purshia tridentata, 346
 Pussytoes, Parlin's, 18
 Small, 17

- Pycnanthemum virginianum*, 8,117
Pyrola americana, 8
 elliptica, 19
 rotundifolia, 8
Pyrus calleryana, 58
 communis, 57
 nivalis, 58
Pyrus communis, in Ontario, Distribution and History of Naturalized Common Pear, 57
- Québec, de 1978 à 2007, Les collisions d'oiseaux à l'édifice Marly à Sainte-Foy, 153
 Québec, Differential Footload of Male and Female Fisher, *Martes pennanti*, in, 269
 Québec, Factors Influencing the Abundance of Berry Plants for Black Bears, *Ursus americanus*, in, 212
 Québec, Habitat Parameters and Small Mammal Associations of the Gaspe Shrew, *Sorex gaspensis*, in the Eastern Gaspé Peninsula, 118
Quercus sp., 61,73,265
 agrifolia, 80
 alba, 17,265
 borealis, 265
 ruber, 106,153
 rubra var. *rubra*, 16
 velutina, 6,265
 Quiscale, 154
 bronzé, 156
Quiscalus quiscula, 156
- Rabbit-Tobacco, Blunt-leaf, 117
 Rabbitbrush, Common, 346
 Rabeni, C.F., 303
 Raccoon, 47,60,176
 Raccoon, *Procyon lotor*, Range Extension in Northern Alberta, Evidence of, 176
 Ragweed, Annual, 18
Ramalina farinacea, 200
 roesleri, 200
Rangifer tarandus, 179,199,231,324
 tarandus caribou, 231
Ranunculus fascicularis, 20,94
 hispidus var. *hispidus*, 7
 rhomboideus, 6
 Raspberry, 212
 Black, 20
 Common Red, 17
 Purple-flowering, 19
 Rat, Ord's Kangaroo, 99
 Ratfish, Spotted, 124
 Ratfish, Counted at an Automated Underwater Observation Station in the Strait of Georgia, British Columbia, Abundance Trends for *Hexanchus griseus*, Blunt-nose Sixgill Shark, and *Hydrolagus colliciei*, Spotted, 124
 Rattlesnake-root, Tall, 20
 White, 20
 Raven, Common, 32,268
 Red-cedar, Eastern, 17
 Redhead, 24
 Redosier, 19
 Redroot, Prairie, 19
Regulus calendula, 156
 satrapa, 156
 Reindeer, 179
- Reiter, M.E., C.W. Boal, and D.E. Andersen. Anurans in a Subarctic Tundra Landscape Near Cape Churchill, Manitoba, 129
Reithrodontomys megalotis, 345
 megalotis dychei, 345
 megalotis megalotis, 345
Reithrodontomys megalotis, in Southern British Columbia, Dynamics of Peripheral Populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest Mice, 345
 Renard, A., M. Lavoie and S. Larivière. Differential Footload of Male and Female Fisher, *Martes pennanti*, in Québec, 269
Rhus aromatica var. *aromatica*, 6
 glabra, 20
 typhina, 8
Ribes sp., 212
 americanum, 214
 glandulosum, 212
 lacustre, 214
 triste, 214
 Ridgway, M.S., 40
 Ringlet, Inornate, 108
Rinodina turfacea, 200
 Roberts, N.M., C.F. Rabeni, J.S. Stanovick and D.A. Hamilton. River Otter, *Lontra canadensis*, Food Habits in the Missouri Ozarks, 303
 Robin's-plantain, 18
 Rockcress, Hairy, 18
 Holboell's, 19
 Hybrid, 18
 Rockwell, R., L. Gormezano and D. Hedman. Grizzly Bears, *Ursus arctos*, in Wapusk National Park, Northeastern Manitoba, 323
 Roitelet, 154
 à couronne dorée, 156
 à couronne rubis, 156
Rosa sp., 31,52,212
 acicularis ssp. *acicularis*, 6
 acicularis ssp. *sayi*, 117
 blanda, 117
 blanda var. *blanda*, 6
 carolina var. *carolina*, 20
 Rose, 52,212
 Carolina, 20
 Prickly, 17,117
 Smooth, 17,117
 Wild, 31
 Rosette Rock, White-hair, 17
 Roy, J., Reviews by, 277,278,280
Rubus sp., 212
 acaulis, 214
 allegghaniensis, 106,214
 alleggheniensis var. *alleggheniensis*, 17
 chamaemorus, 214,324
 flagellaris, 19
 idaeus, 212
 idaeus ssp. *idaeus*, 17
 occidentalis, 20
 odoratus, 214
 odoratus var. *odoratus*, 19
 pubescens, 214
Rudbeckia hirta, 106
 hirta var. *hirta*, 17
 hirta var. *pulcherrima*, 109

- Ruess, R.W., 29
Rumex acetosella, 106
 Running-Pine, Northern, 116
 Southern, 116
 Rush, Greene's, 108
 Tall Scouring, 18
 Rye, Nodding Wild, 20
 Slender Wild, 16
- Sagebrush, Big, 53,346
 Sagewort, Prairie, 346
Salix sp., 30,61,201,299
 humilis var. *humilis*, 17
 petiolaris, 20
 Salmon, Coho, 329
 Salsify, Yellow, 346
Salvelinus fontinalis, 40
Salvelinus fontinalis, Repeatability of Foraging Tactics in
 Young Brook Trout, 40
Sambucus nigra ssp. *canadensis*, 20
 pubens, 212
 Samson, C., 212
 Sand-verbena, Small-flowered, 101
 Sander-Regier, R., Review by, 286,365
 Sandpiper, Semipalmated, 274
 Sandpipers, *Calidris pusilla*, at Farrier's Cove, Shepody Bay,
 New Brunswick, Cliff Roosting by Migrant Semi-
 palmated, 274
 Sandwort, Thyme-leaf, 19
 Sanges, 154
Sanicula marilandica, 19
 Sargeant, G.A., 221
 Sargent, P.S., D.A. Methven, R.G. Hooper, and C.H. McKen-
 zie. A Range Extension of the Atlantic Silverside,
 Menidia menidia, to Coastal Waters of Southwestern
 Newfoundland, 338
 Sarsaparilla, Bristly, 212
 Wild, 18,212
 Saskatoon, 52
Saxifraga virginicensis, 7
 Saxifrage, Early, 18
Sayornis sayi, 268
Scalopus aquaticus, 74
Scapanus townsendii, 267
 Scaup, Lesser, 21
 Scaup, *Aythya affinis*, Eye Colour, Aging, and Decoy Trap
 Bias in Lesser, 21
Schinia avemensis, 101
 bimatrix, 101
Schizachne purpurascens, 18
Schizachyrium sp., 106
scoparium, 8
scoparium var. *scoparium*, 6
Schizocosa avida, 111
saltatrix, 111
 Schuler, M. and R.P. Thiel. Annual vs. Multiple-Year Home
 Range Sizes of Individual Blanding's Turtles, *Emy-
 doidea blandingii*, in Central Wisconsin, 61
Scomber scombrus, 340
 Scouring-Rush, Tall, 116
 Variegated, 106
Scrophularia lanceolata, 20
 Sculpin, 304,340
 Seburn, C.N.L., 158
 Seburn, D., Review by, 372
 Seburn, D.C., C.N.L. Seburn, and W.F. Weller. A Localized
 Decline in the Western Chorus Frog, *Pseudacris
 triseriata*, in Eastern Ontario, 158
 Sedge, Back's, 19
 Clustered, 116
 Dry-Spike, 16,116
 Great Plains Flat, 17
 Houghton's, 116
 Houghton's Flat, 116
 Merritt Fernald's, 17,116
 Muhlenberg's, 17
 Pennsylvania, 16,116
 Richardson's, 17
 Shaved, 17,116
Seiurus aurocapilla, 155
 noveboracensis, 156
Selaginella rupestris, 6,106
 Selfheal, Common, 18
 Seneca-snakeroot, 18
 Serviceberry, 212
 Allegheny, 18,116
 Downy, 18,116
 Round-leaf, 18
 Running, 16,116
 Shark, 340
 Bluntnose Sixgill, 124
 Cookiecutter, 263
 Shark, and *Hydrolagus coliei*, Spotted Ratfish, Counted at an
 Automated Underwater Observation Station in the
 Strait of Georgia, British Columbia, Abundance
 Trends for *Hexanchus griseus*, Bluntnose Sixgill, 124
Shepherdia canadensis, 6
 Simon Memorial Scholarship Award, Dr. Neal, 194
 Shinleaf, 19
 Shrew, Gaspé, 118
 Long-tailed, 118
 Masked, 120
 Short-tailed, 120
 Smoky, 119
 Wandering, 347
 Water, 120
 Shrew, *Sorex gaspensis*, in the Eastern Gaspé Peninsula, Qué-
 bec, Habitat Parameters and Small Mammal Associa-
 tions of the Gaspé, 118
 Sidebells, 20
Silene antirrhina, 18
 cucubalus, 117
 vulgaris, 106
 Silverside, Atlantic, 338
 Inland, 339
 Silverside, *Menidia menidia*, to Coastal Waters of South-
 western Newfoundland, A Range Extension of the
 Atlantic, 338
 Simpler's-joy, 19
Sisymbrium altissimum, 346
Sisyrinchium montanum var. *montanum*, 18
Sitta carolinensis, 154
 Sittelle à poitrine blanche, 154
 Skipper, Delaware, 109
 Leonard's, 108
 Skunk, Striped, 80
 Skunks, *Mephitis mephitis*, A Group Defense Incident Involv-
 ing Juvenile Striped, 80
 Smelt, Rainbow, 340
Smilacina racemosa, 17

- stellata*, 16
Smilax herbacea, 18
 Smith, C.M., Review by, 285
 Smith, R., Review by, 190
 Smoke, Prairie, 94
 Snake, Eastern Rat, 73
 Great Basin Gopher, 140
 Hognose, 94
 Northern Pine, 139
 Northern Water, 73
 Snakeroot, Seneca, 1
 Snow, D., 262
 Snowberry, 52
 Common, 17
Solidago arguta, 8
 arguta var. *arguta*, 7
 bicolor, 7
 canadensis var. *canadensis*, 17
 gigantea, 18
 hispida var. *hispida*, 20
 juncea, 8, 106
 nemoralis, 106
 nemoralis var. *nemoralis*, 8, 117
 rugosa ssp. *rugosa* var. *rugosa*, 19
 Solomon's Seal, False, 17
 King, 20
 Starry False, 16, 116
 Somers, M. and R.P. Thiel. Use of Winter Dens by Porcupines, *Erethizon dorsatum*, in Wisconsin, 45
Sorbus americana, 212
 decora, 214
Sorex cinereus, 120
 dispar, 118
 fumeus, 119
 gaspensis, 118
 hoyi, 121
 palustris, 120
 vagrans, 347
Sorex gaspensis, in the Eastern Gaspé Peninsula, Québec, Habitat Parameters and Small Mammal Associations of the Gaspé Shrew, 118
Sorghastrum sp., 106
 nutans, 6
 Sorrel, Common Sheep, 117
 Sovada, M.A., 312
 Sparrow, Clay-coloured, 111
 Grasshopper, 111
Spharagemon bolli bolli, 109
 collare, 109
 Spike-moss, Ledge, 18, 117
Spiraea betulifolia, 53
 tomentosa, 106
Spiraea, Birch-leaved, 53
Spiranthes casei var. *casei*, 20
 cernua, 106
 lacera var. *lacera*, 20
Spiraverpa senax, 111
Spizella arborea, 156
 pallida, 111
Sporobolus cryptandrus, 6, 106
 Spruce, 205, 222
 Black, 176, 206, 213, 231
 Engelmann, 52
 White, 30, 116, 176, 199, 206, 231
 Spruce, *Picea glauca*, Tree Islands on a Calcareous Beach Ridge in Northeastern Manitoba, A Survey of Lichens and Bryophytes in White, 199
 Squirrel, North American Red, 65
 Squirrel, *Tamiasciurus hudsonicus*, Mothers Relocate Their Young? A Predation-based Hypothesis, Why do North American, 65
 St. John's-wort, Great, 8
 Stanovick, J.S., 303
 Star, Blazing, 1
 Starwort, Long-stalk, 19
 Steeplebush, 117
Stellaria longipes, 19
Steotoda albomaculata, 111
 Stickleback, Fourspine, 340
 Threespine, 340
 Strawberry, American, 212
 Virginia, 16, 116
Streptopus roseus, 212
 Streptopus, Pink, 212
Strix nebulosa, 78
Strix nebulosa, Nest, Dytiscid Beetle Remains Discovered in a Pellet from a Great Gray Owl, 78
Sturnus vulgaris, 154
 Sullivan, D.S., 345
 Sullivan, T.P. and D.S. Sullivan. Dynamics of Peripheral Populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in Southern British Columbia, 345
 Sumac, Fragrant, 17
 Smooth, 20
 Stag-horn, 16
 Sundew, Round-leaf, 108
 Sunfish, 303
 Sunflower, Pale-leaf Woodland, 17, 116
 Woodland, 17, 116
 Surette, S.J.E., 274
 Sweet-fern, 17
 Sweetvetch, Alpine, 67
 Switchgrass, 1
Sylvilagus transitionalis, 170
Symphoricarpos albus, 52
 albus var. *albus*, 17
 oreophilus, 52
Symphotrichum amethystinum, 20
 ericoides var. *ericoides*, 8
 lateriflorum var. *lateriflorum*, 19
 novae-angliae, 18
 oolentangiense var. *oolentangiense*, 8
 puniceus, 19
 undulatum, 8
 urophyllum, 8
Synaptomys cooperi, 120

Tachycineta bicolor, 154
Taenia pisiformis, 169
Taenidia integerrima, 7
 Taki, H., P.G. Kevan and Y. Yamaura. Effects of Forest Cover on Fruit Set in the Woodland Herb, *Maianthemum canadense* (Liliaceae), 234
 Tamarack, 176, 231
Tamias amoenus, 347
 striatus, 73
Tamias striatus, and Hairy-tailed Mole, *Parascalops breweri*, in Kawartha Highlands Provincial Park, Ontario, Swimming Eastern Chipmunks, 73

- Tamiasciurus hudsonicus*, 65
Tamiasciurus hudsonicus, Mothers Relocate Their Young? A Predation-based Hypothesis, Why do North American Red Squirrel, 65
Taraxacum officinale sp. *officinale*, 67
Taraxacum officinale, in Denali National Park and Preserve, Alaska, Evidence for Higher Soil Temperature and Potassium Promoting Invasion of the Common Dandelion, 67
Tauto onitis, 247
Tauto onitis, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on Tautog, 247
Tautog, 247
Tautog in Nova Scotia and New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the, 247
Tautog, *Tauto onitis*, at Western Arm Jeddore Harbour, Halifax County, Nova Scotia, Canada, with a Review of Evidence for Resident Relict Populations of the Tautog in Nova Scotia and New Brunswick, Winter Predation by River Otter, *Lontra canadensis*, on, 247
Tautoglabrus adspersus, 247,340
Taxidea taxus, 111
Teaberry, Eastern, 20,116
Thalictrum dioicum, 18
Thiel, R.P., 45,61,264
Thimbleweed, 19
 Long-head, 16,116
Thistle, Field, 18,116
Thrush, 154
Thuidium sp., 200
Thuja occidentalis, 18,106
Thunnus thynnus, 340
Tibellus oblongus, 111
Tick-trefoil, Naked-flower, 20
 Panicked-leaf, 19
 Pointed-leaf, 18
 Showy, 17,116
Tilia sp., 228
 americana var. *americana*, 19
Timm, B.C., 316
Toad, 94
 American, 160
Tomcod, Atlantic, 340
Tomentypnum nitens, 200
Top-minnow, 304
Tortula ruralis, 108,200
Toxicodendron rydbergii, 8
Tragopogon dubius, 346
Trailing-arbutus, 20
Trapp, J.R., P. Beier, C. Mack, D.R. Parsons, and P.C. Paquet.
 Wolf, *Canis lupus*, Den Site Selection in the Rocky Mountains, 49
Treanor, J.J., 171
Treefrog, Gray, 160
Trientalis borealis, 20
Trifolium stoloniferum, 8
Trillium grandiflorum, 18
Trillium, White, 18
Trimorous ninus, 110
Triodanis perfoliata, 20
Triosteum perfoliatum, 20
Tripterocalyx micranthus, 101
Trochosa terricola, 111
Trout, Brook, 40
 Cutthroat, 332
 Rainbow, 43
Trout, *Salvelinus fontinalis*, Repeatability of Foraging Tactics in Young Brook, 40
Tuckermannopsis sp., 201
 americana, 200
 chlorophylla, 200
 sepincola, 200
Tulostoma sp., 108
Tumble-mustard, Tall, 346
Tuna, Bluefin, 340
Tunicate, Golden Star, 342
 Violet, 342
Turdus magratorius, 154
Turtle, Blanding's, 61
Turtles, *Emydoidea blandingii*, in Central Wisconsin, Annual vs. Multiple-Year Home Range Sizes of Individual Blanding's, 61
Tyran huppé, 154
Ulmus sp., 226
Umbellularia californica, 80
Urocyon cinereoargenteus, 169
Urocyon cinereoargenteus, in New Brunswick: a Climate-change Mediated Range Expansion?, First Occurrence of the Grey Fox, 169
Urophycis tenuis, 340
Ursus americanus, 71,111,167,212
 arctos, 76,172,323
 arctos horribilis, 272
 horribilis, 31
 maritimus, 132,324
Ursus americanus, in Quebec, Factors Influencing the Abundance of Berry Plants for Black Bears, 212
Ursus arctos, in Montana, Alberta, and Wyoming, Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, 76
Ursus arctos, in Wapusk National Park, Northeastern Manitoba, Grizzly Bears, 323
Usnea sp., 200,231
 lapponica, 200
Vaccinium sp., 212
 corymbosum, 8
 angustifolium, 6,214
 cespitosum, 214
 globulare, 52
 myrtilloides, 214
 ovalifolium, 214
 oxycoccos, 214
 scoparium, 52
 uliginosum, 214,324
 vitis-idaea, 214
Valpicida pinastri, 202
Venus'-looking-glass, Clasp-leaf, 20
Verbascum thapsus, 346
Verbena hastata var. *hastata*, 19
 stricta, 6
Vermivora chrysoptera, 156
 peregrina, 155

- ruficapilla*, 156
 Vervain, Hoary, 18
 Vetch, American, 346
 Vetchling, Cream, 19
Viburnum sp., 212
 acerifolium, 18
 cassinoides, 214
 edule, 212
 lentago, 19, 214
 rafinesquianum, 19, 214
Viburnum, 212
Vicia americana, 346
Viola adunca, 117
 adunca var. *adunca*, 6
 affinis, 20
 canadensis var. *canadensis*, 19
 pubescens var. *pubescens*, 19
 sagittata var. *ovata*, 6
 Violet, Arrow-leaf, 17
 Canadian White, 19
 Downy Yellow, 19
 Hook-spur, 17, 117
 Sand, 20
Vireo olivaceus, 156
Vireo, 154
Viréo, 154
 aux yeux rouges, 156
 Virginia-creeper, 19
Vitis aestivalis, 9
 riparia, 16, 106
 Vole, 346
 Long-tailed, 347
 Meadow, 120
 Montane, 347
 Red-backed, 120
Volsella modiolus, 250
Vulpes vulpes, 31, 167, 270, 271, 320
Vulpia octoflora, 346
Vulpicida pinastris, 200

 Wade, J., 327
 Warbler, 154
 Pine, 111
 Wasp, 110
 Way, J.G. Eastern Coyotes, *Canis latrans*, Observed Feeding on Periodical Cicadas, *Magicicada septendecim*, 271
 Way, J.G. and B.C. Timm. Nomadic Behavior of an Old and Formerly Territorial Eastern Coyote, *Canis latrans*, 316
 Weasel, Short-tailed, 65, 347
 Weller, W.F., 158
 Whale, False Killer, 263
 Killer, 263
 Wheatgrass, 67
 Bluebunch, 346
 Crested, 346
 White-top, Parasol, 20
 Wilcox, J.T., and B.N. Larsen. A Group Defense Incident Involving Juvenile Striped Skunks, *Mephitis mephitis*, 80
 Wildebeest, 81
 Willow, 30, 61, 299
 Meadow, 20
 Prairie, 17
Wilsonia canadensis, 155
 pusilla, 155
 Wintergreen, American, 8
 Wisconsin, Annual vs. Multiple-Year Home Range Sizes of Individual Blanding's Turtles, *Emydoidea blandingii*, in Central, 61
 Wisconsin, Characteristics of Porcupine, *Erethizon dorsatum*, Winter Den-sites in Living Trees in, 264
 Wisconsin, Use of Winter Dens by Porcupines, *Erethizon dorsatum*, in, 45
 Wolf, 31, 49, 172, 173, 176, 202, 222, 232, 273, 316, 324
 Gray, 76
 High Arctic, 142
 Wolf, *Canis lupus arctos*, in Northeast Greenland, 1978-1998, Reproduction and Mortality of the High Arctic, 142
 Wolf, *Canis lupus*, Den Site Selection in the Rocky Mountains, 49
 Wolverine, 270
 Wolves, *Canis lupus*, from Ages 2 to 24 Months, Weight Changes in Wild, 173
 Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and Wyoming, Gray, 76
 Wood-aster, Large-leaf, 18
 Wood-rush, Hairy, 19
 Woodpecker, 154
 Black, 229
 Pileated, 226
 Woodpeckers, *Dryocopus pileatus*, Foraging in Suburban Habitats in New Brunswick, Pileated, 226
 Woodruff, S.P., 76
 Worm, Giant Kidney, 162
 Water, 164
 Worm, *Dictyophyma renale*, Prevalence in Minnesota Mink, *Mustela vison*, Spatial and Temporal Differences in Giant Kidney, 162
 Wormwood, Pacific, 17
 Wright, J.D. Bullsnake, *Pituophis catenifer sayi*, Nesting Biology in Alberta, 138
 Wyoming, Gray Wolves, *Canis lupus*, Killed by Cougars, *Puma concolor*, and a Grizzly Bear, *Ursus arctos*, in Montana, Alberta, and, 76

Xanthoria sp., 200
 candelaria, 200
Xysticus triguttatus, 111

 Yamaura, Y., 234
 Yellow-loosestrife, Four-flower, 20
 Yellow-pimpernel, 18

Zanthoxylum americanum, 20
Zelotes hentzi, 111
Zigadenus elegans ssp. *glaucus*, 20
Zonotrichia albicollis, 156
Zostera marina, 338

Index to Book Reviews

Botany

- Bixia, X., X. Chen, D. Zhang, W. Liang, Q. Zhong, S. Wang, R. Zhang, A. Li, X. Pan, Y. Wen, H. Zhuang, T. Wu, Z. Gu, X. Wang, J. Yu, and M. Hu. *Woody Starch Plants in China*, 187
- McPherson, S. *Glistening Carnivores: The Sticky-Leaved Insect-Eating Plants*, 280
- Northwest Plateau Institute of Biology. *Aweto in China*, 86
- Smith, W.R. *Trees and Shrubs of Minnesota*, 281
- Tongpei, Y., S. Junyi, M. Lisha, W. Haitao and Y. Lin. *Monograph on Bamboo in China*, 361
- Xinqi, C., J. Zhanhe and L. Yibo. *Chinese Wild Orchids*, 87
- Yuhu, W. *The Vascular Plants and Their Eco-Geographical Distribution in the Qinghai-Tibet Plateau Area*, 88
- Yumei, W. *Aromatic Plants in China*, 85

Environment

- Cain, M.L., W.D. Bowman, and S.D. Hacker. *Ecology*, 190
- Chaudhary, R., T.H. Aase, O.R. Vetaas, and B.P. Subedi. *Local Effects of Global Changes in the Himalayas: Manang Nepal*, 367
- Curry, G. and C.J. Humphries. *Biodiversity Databases: Techniques, Politics and Applications*, 365
- Guoliang, L., F. Weidong and L. Kun. *Major Invasive Organisms in Agriculture of China*, 283
- Haslam, S.M. *The Riverscape and the River*, 286
- Hemming, J. *Tree of Rivers: The Story of the Amazon*, 362
- Jordan, J.A. *Plains Apache Ethnobotany*, 365
- MacLaren, I. *Culturing Wilderness in Jasper National Park: Studies in Two Centuries of Human History in the Upper Athabasca River Watershed*, 285
- McPherson, S. *Lost Worlds of the Guiana Highlands*, 284
- Primack, R.B. *A Primer of Conservation Biology*, 89
- Revkin, A. *The Burning Season*, 188

Miscellaneous

- Anthony, L. *Snakebit: Confessions of a Herpetologist*, 372
- Arbour, C. and J. Irving. *Choosing Wildness: My Life Among the Ospreys*, 370
- Czajkowski, C. *A Mountain Year: Nature Diary of a Wilderness Dweller*, 369
- Jackson, J.A., W.E. Davis, Jr., and J. Tautin. *Bird Banding in North America: The First Hundred Years*, 288

- Normont, C. *Return to Warden's Grove: Science, Desire, and the Lives of Sparrows*, 371
- Nowak, E. *Wissenschaftler in turbulenten Zeiten: Erinnerungen an Ornithologen, Naturschuetzer und andere Naturkundler [Scientists in troubled times: Memories about Ornithologists, Conservationists and other Naturalists]*, 191
- O'Connor, T. *The Archaeology of Animal Bones? Second Printing*, 371
- Schake, L.M. *On the Wings of Cranes: Larry Walkinshaw's Life Story*, 286

Zoology

- Bergerud, A.T., S.N. Luttich, and L. Camps. *The Return of Caribou to Ungava*, 279
- Birkhead, T. *The Wisdom of Birds: An Illustrated History of Ornithology*, 184
- Crother, B.I. *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding*, Sixth Edition, 357
- del Hoyo, J. *HBW IBC*, 84
- del Hoyo, J., A. Elliott and D.A. Christie. *Handbook of the Birds of the World Volume 10*, 182
- del Hoyo, J., A. Elliott and D.A. Christie. *Handbook of the Birds of the World Volume 12*, 183
- del Hoyo, J., A. Elliott and D.A. Christie. *Handbook of the Birds of the World. Volume 13. Penduline-tits to Shrikes*, 278
- Franke, V. and J. Andrews. *Rattlers, Peepers & Snappers*, 85
- Gaston, A. *Seabirds: A Natural History*, 359
- Hamilton, G. *Arctic Fox: Life at the Top of the World*, 358
- Kaiser, G.W. *The Inner Bird ? Anatomy and Evolution*, 359
- Marent, T. *Frog*, 84
- Prynn, D. *Amur Tiger*, 186
- Sept, J.D. *A Photographic Guide to Seashore Life in the North Atlantic? Canada to Cape Cod*, 280
- Shuford, W.D. and K.C. Molina. *Ecology and Conservation of the Birds of the Salton Sink: An Endangered Ecosystem*, 185
- Uhlenbroek, C. *Animal Life*, 83
- Weir, R. *Birds of the Kingston Region [Second Edition]*, 277
- Winn, M. *Central Park in the Dark ? More Mysteries of Urban Wildlife*, 184

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Alliance of Natural History Museums of Canada Annual Meeting and Awards 2008 — USA National Phenology Network — <i>Marine Turtle Newsletter</i> (122) October 2008 — Ontario Crayfish — Canadian Association of Herpetologists Association canadienne des herpetologists Bulletin 16(1) Fall 2008	376
---	-----

The Ottawa Field-Naturalists' Club Awards for 2007	379
--	-----

Index to The Canadian Field-Naturalist Volume 122	By LESLIE CODY	383
---	----------------	-----

Advice to Contributors	402
------------------------	-----

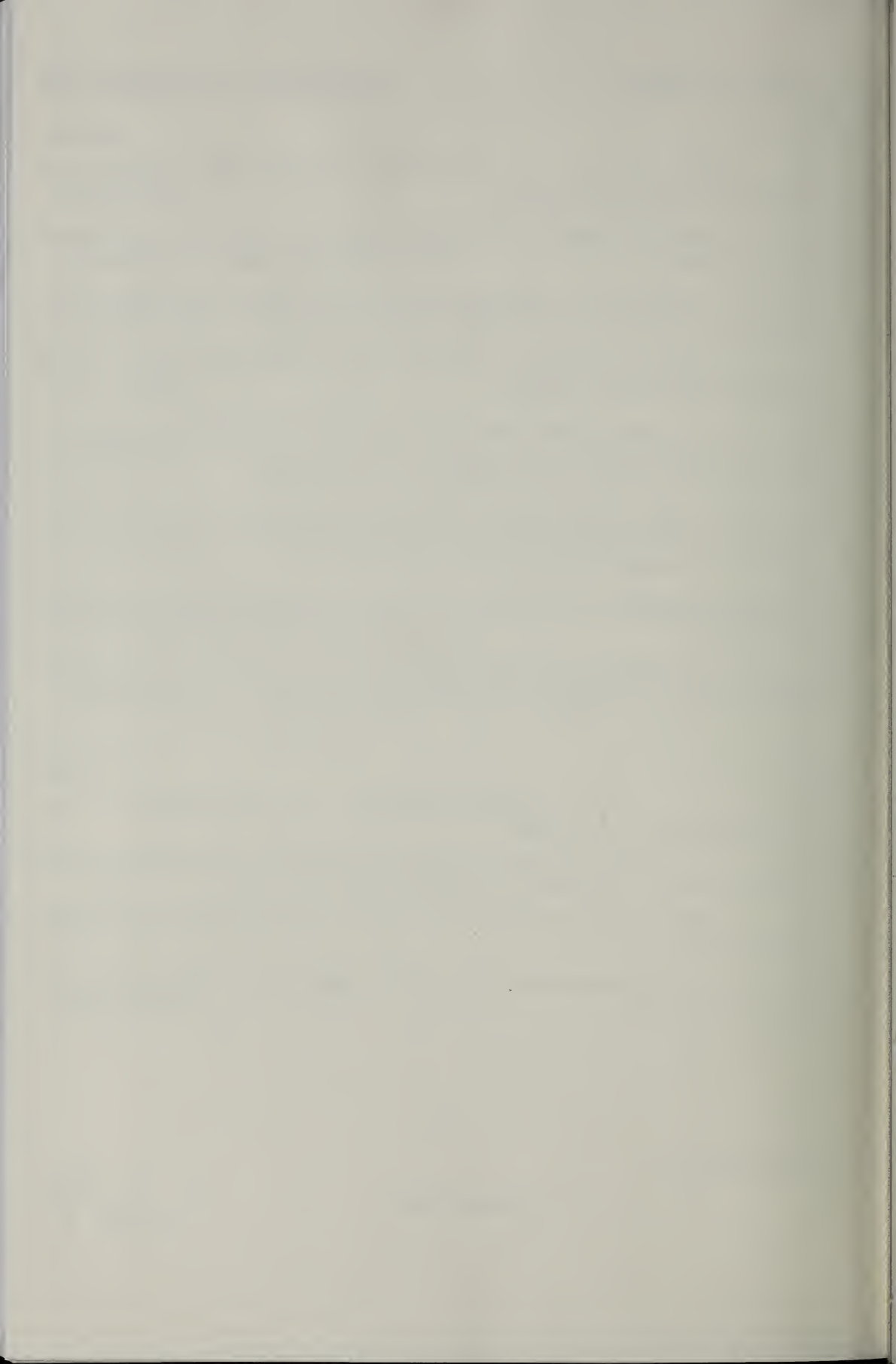
Mailing date of the previous issue 122(3) 29 January 2010

Articles

- The density of Beaver, *Castor canadensis*, activities along Camrose Creek, Alberta, within differing habitats and management intensity levels
BETHANY M. LOATES and GLEN T. HVENEGAARD 299
- River Otter, *Lontra canadensis*, food habits in the Missouri Ozarks
NATHAN M. ROBERTS, CHARLES F. RABENI, JOHN S. STANOVICK, and DAVID A. HAMILTON 303
- Contaminant levels in eggs of American White Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, North Dakota
PAMELA J. PIETZ, MARSHA A. SOVADA, CHRISTINE M. CUSTER, THOMAS W. CUSTER, and KEVIN M. JOHNSON 312
- Nomadic behavior of an old and formerly territorial eastern Coyote, *Canis latrans*
JONATHAN G. WAY and BRAD C. TIMM 316
- Grizzly Bears, *Ursus arctos*, in Wapusk National Park, Northeastern Manitoba
ROBERT ROCKWELL, LINDA GORMEZANO, and DARYLL HEDMAN 323
- Critical habitat and the conservation ecology of the freshwater parasitic lamprey, *Lampetra macrostoma*
R. J. BEAMISH and J. WADE 327
- A range extension of the Atlantic Silverside, *Menidia menidia*, to coastal waters of southwestern Newfoundland
PHILIP S. SARGENT, D. A. METHVEN, ROBERT G. HOOPER, and CYNTHIA H. MCKENZIE 338
- Dynamics of peripheral populations of Great Basin Pocket Mice, *Perognathus parvus*, and Western Harvest Mice, *Reithrodontomys megalotis*, in southern British Columbia
THOMAS P. SULLIVAN and DRUSCILLA S. SULLIVAN 345

Book Reviews

- ZOOLOGY : Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding, Sixth Edition — Arctic Fox: Life at the Top of the World — The Inner Bird: Anatomy and Evolution — Seabirds: A Natural History 357
- BOTANY : Monograph on Bamboo in China 361
- ENVIRONMENT : Tree of Rivers: The Story of the Amazon — Plains Apache Ethnobotany — Biodiversity Databases: Techniques, Politics and Applications — Local Effects of Global Changes in the Himalayas: Manang Nepal 362
- MISCELLANEOUS : A Mountain Year: Nature Diary of a Wilderness Dweller — Choosing Wildness: My Life Among the Ospreys — Return to Warden's Grove: Science, Desire, and the Lives of Sparrows — The Archaeology of Animal Bones: Second Printing — Snakebit: Confessions of a Herpetologist 369
- NEW TITLES 373



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